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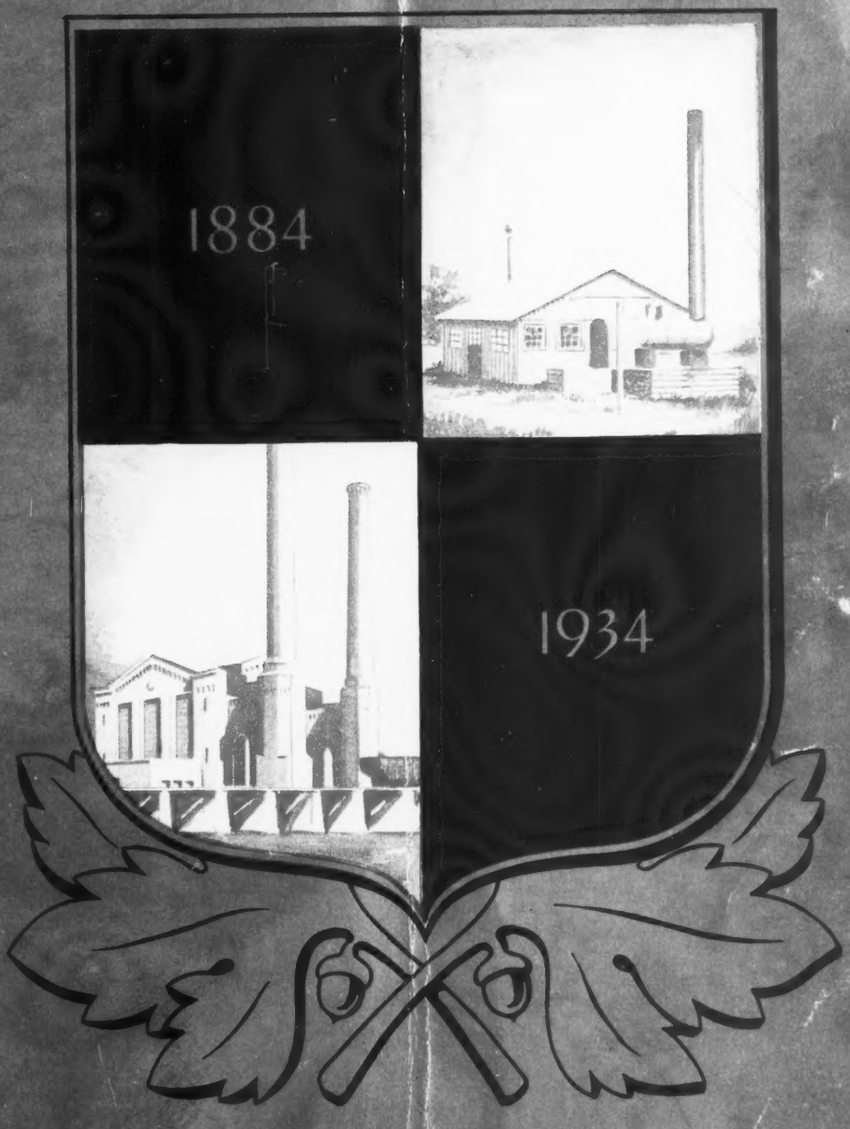
DETROIT

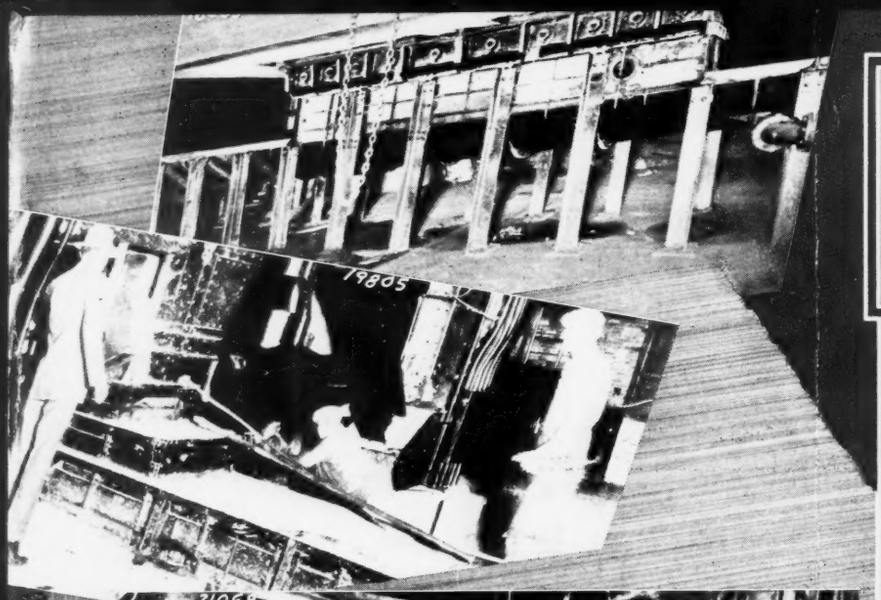
POWER

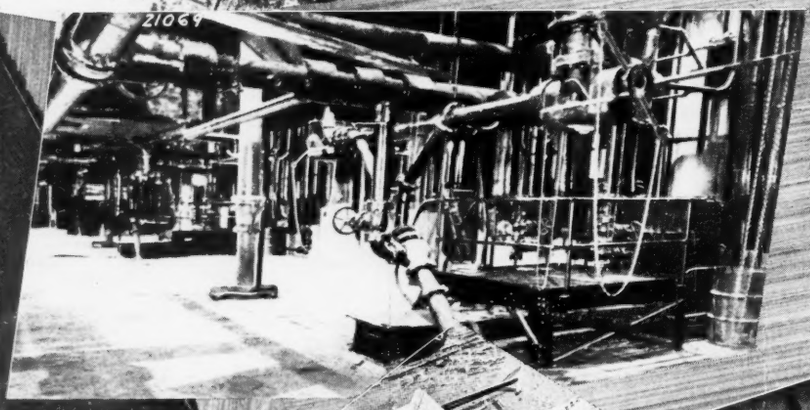
POWER GENERATION, TRANSMISSION, APPLICATION
AND ATTENDANT SERVICES IN ALL INDUSTRIES

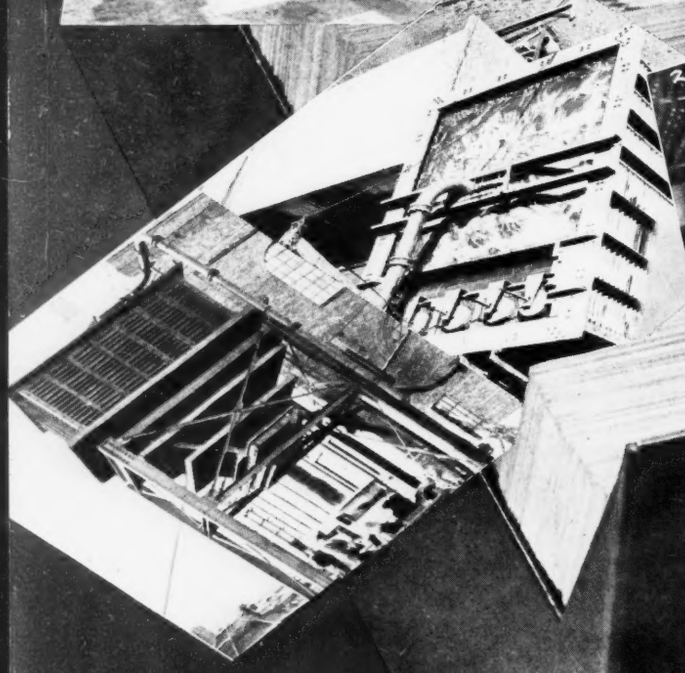
JUNE 1934

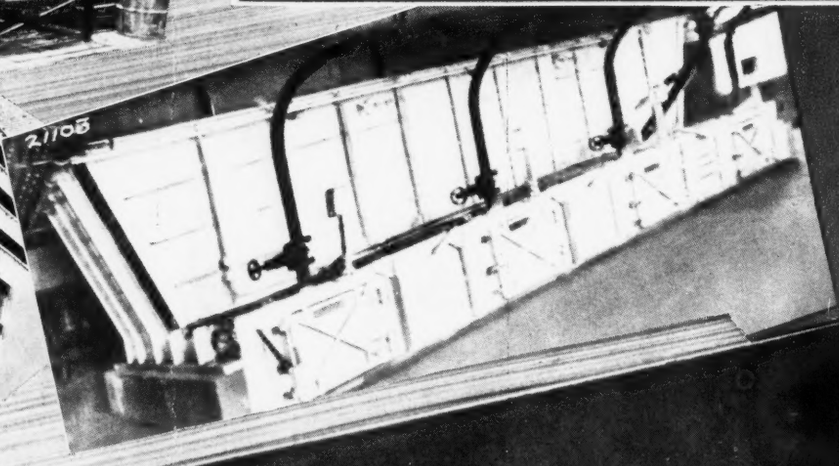


IN COMMEMORATION OF
THE FIFTIETH ANNIVERSARY



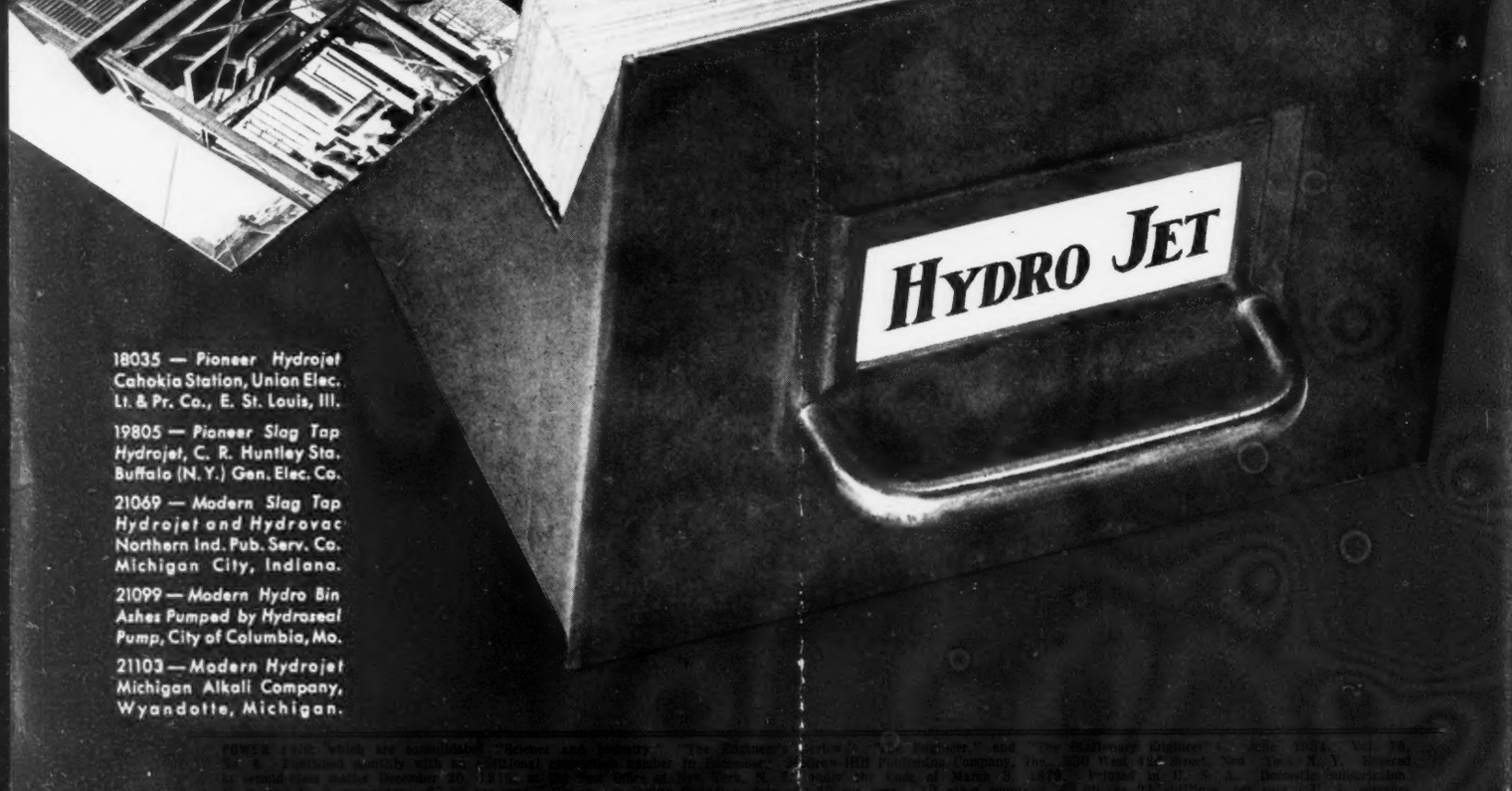






The Authority of Experience

In the early 1920's, higher boiler ratings and the increasing use of ash quenching water found existing ash gates impotent and the ash tunnel became a veritable maelstrom of water, ashes, dust and fumes. Born then of necessity, the A-S-H Type "C" Gate still meets every requirement of tightness and reliability . . . Next came the quest of utter cleanliness and simplicity in the removal of ashes and in 1924, a Pioneer Hydrojet System at Cahokia, then the largest powdered coal burning plant in America, proved eminently successful. In 1927, Hydrojet was adapted to the pioneer of slag tap furnaces at Huntley Station. Then, to extend Hydrojet advantages to the disposal of ashes, the Hydroseal Ash Pump and the De-Watering Hydro Bin were soon developed, closely followed by the Hydrovac System for removing dust and siftings . . . Hundreds of plants are now served by the Hydrojet and its allied systems among which is the World's Largest Power Plant (Hudson Avenue Station, Brooklyn Edison Co.) and the World's Largest Boiler (Hell Gate Station, United Electric Light and Power Co.) . . . This experience gives an inimitable authority to our recommendations for the handling of all power plant incombustible. The Allen-Sherman-Hoff Co., 227 South 15th Street, Philadelphia. Offices in Principal Cities.



18035 — *Pioneer Hydrojet* Cahokia Station, Union Elec. Lt. & Pr. Co., E. St. Louis, Ill.

19805 — *Pioneer Slag Tap Hydrojet*, C. R. Huntley Sta. Buffalo (N. Y.) Gen. Elec. Co.

21069 — *Modern Slag Tap Hydrojet and Hydrovac* Northern Ind. Pub. Serv. Co. Michigan City, Indiana.

21099 — *Modern Hydro Bin Ashes Pumped by Hydroseal Pump*, City of Columbia, Mo.

21103 — *Modern Hydrojet* Michigan Alkali Company, Wyandotte, Michigan.

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For high speed power transmission. Data Book 125. Stock List 725.

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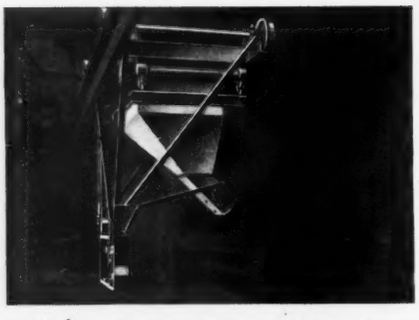
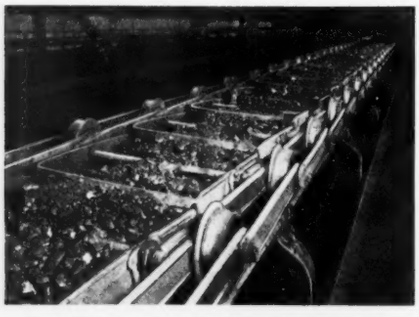
LINK-BELT

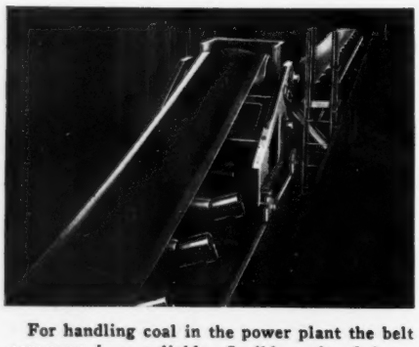
Use LINK-BELT COST-REDUCING CONVEYORS for Coal and Ashes Handling



Weighing and recording coal delivered, is a check on plant efficiency—use Link-Belt Traveling Weigh Larry.



The Peck Overlapping Pivoted Bucket Carrier. The one machine handles both coal and ashes.



For handling coal in the power plant the belt conveyor is a reliable, flexible unit of large capacity and economy.

Prepare your power plant now to take care of future demands. Don't postpone until the eleventh hour. Consult an experienced Link-Belt engineer. Our line is complete. It includes—elevators and conveyors of the bucket, belt, flight, apron, and gravity-discharge-bucket types; skip hoists; weigh larries; coal crushers; water intake screens; locomotive and crawler type cranes; portable conveyors; feeders; bins; gates; etc. Send for catalogs.

LINK-BELT COMPANY

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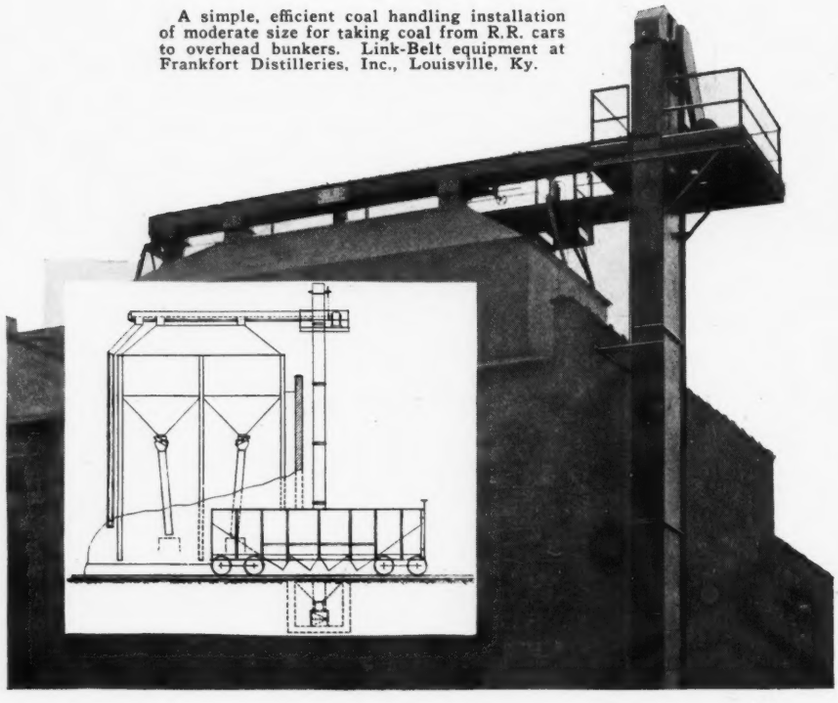
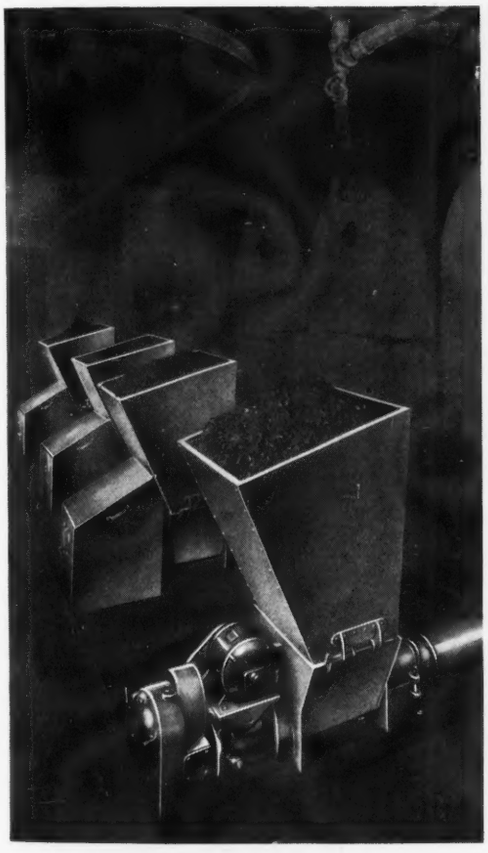
5033-A

A simple, efficient coal handling installation of moderate size for taking coal from R.R. cars to overhead bunkers. Link-Belt equipment at Frankfort Distilleries, Inc., Louisville, Ky.

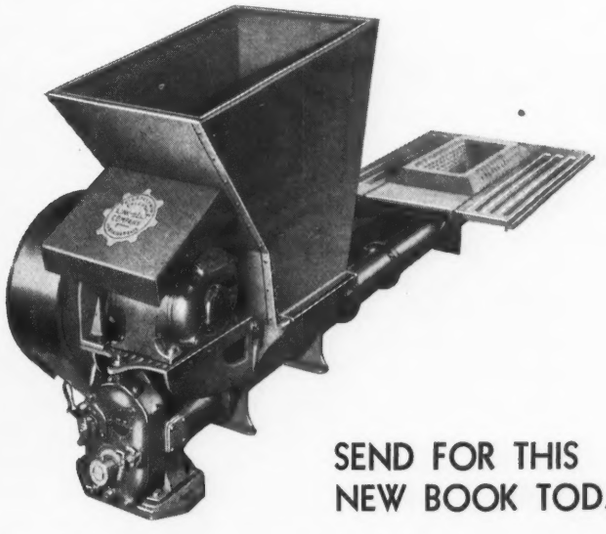


Use the LINK-BELT STOKER *for Boilers up to* 250 H.P.



Link-Belt Controlled Underfeed Firing now makes possible large savings in steam costs for smaller boilers—units 250 down to 10 H.P.

Such modernization often pays for itself in a year or less, with the added benefits of automatic operation and uniform pressures or temperatures. If you are now hand-firing any boiler under 250 H.P., you are missing opportunities for substantial savings. Return the coupon for Book No. 1419 —an interesting study on controlled underfeed firing.



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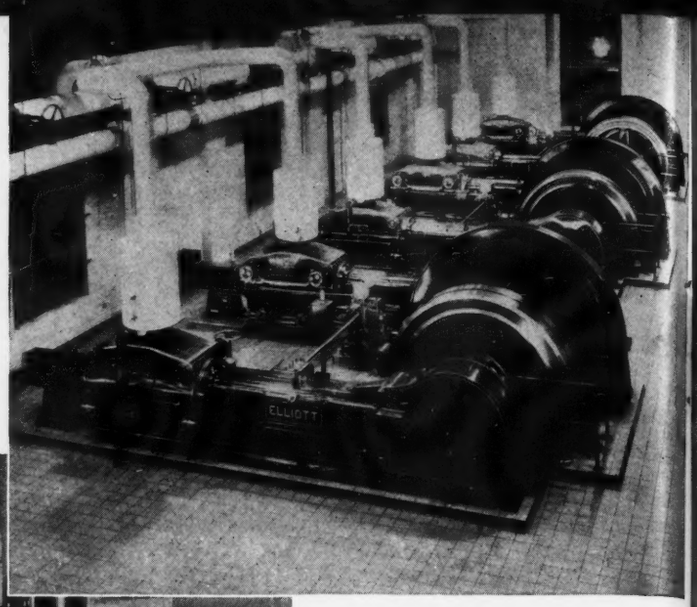
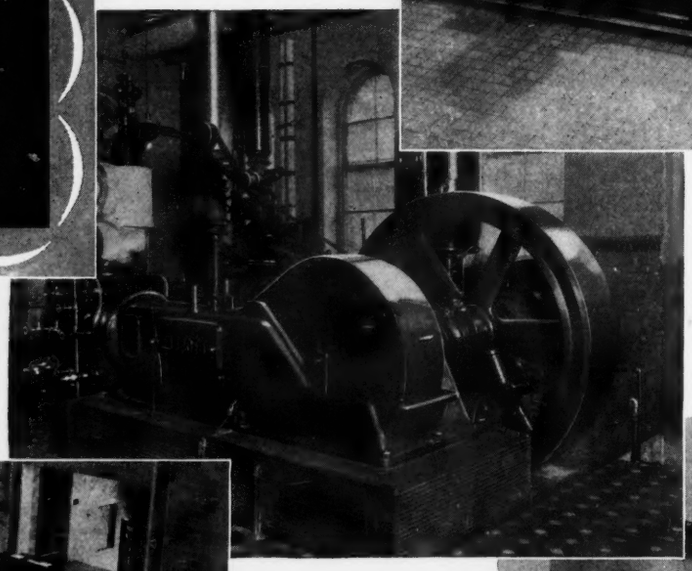
PRIME MOVERS perform with real economy

ENGINES—

At right: Three Elliott 2500-hp., twin engine units serving a large institution.



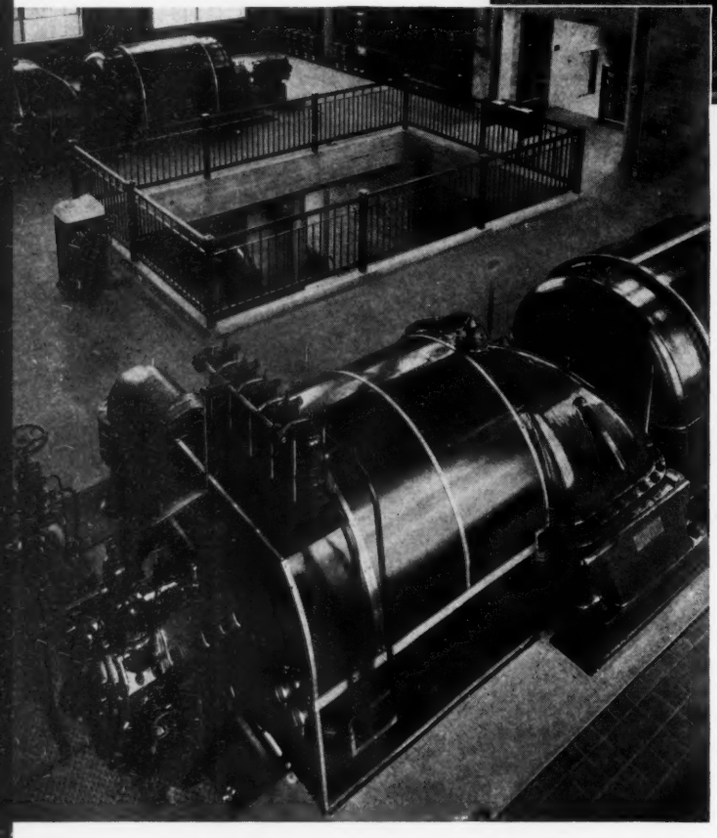


ENGINES—

At left: Elliott four-valve adjustable cut-off engine direct-connected to horizontal compressor.

TURBINE-GENERATORS—

Below: Two Elliott 4000-kw. turbine-generator units in a new municipal power plant.



MECHANICAL DRIVE TURBINES—

At right: Elliott geared mechanical drive turbine driving induced draft fan.

The excellent operating records of ELLIOTT STEAM ENGINES and TURBINES driving generators or mechanical equipment, reflect the sound engineering, fine materials, and special skill combined in their design and fabrication. Unfailing performance is built into them, and this inherent capability is further backed up by the continued interest on the part of the ELLIOTT organization in every one of its prime movers in service.

Since ELLIOTT builds both engines and turbines, ELLIOTT engineers are unprejudiced in helping you decide which prime mover is best for your plant.

If you value dependability in power

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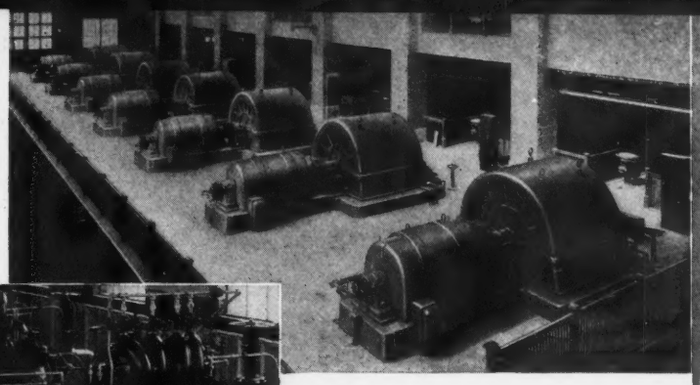
ELLIOTT

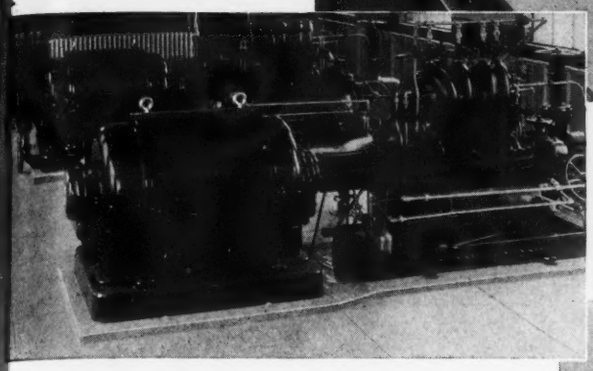
ELECTRICAL EQUIPMENT

is specially built to the job

MOTORS—

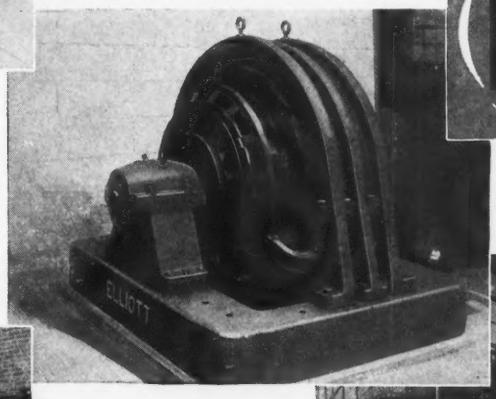
At right: Seven Elliott 3600-r.p.m. synchronous motors driving Elliott blowers in a sewage treatment works.





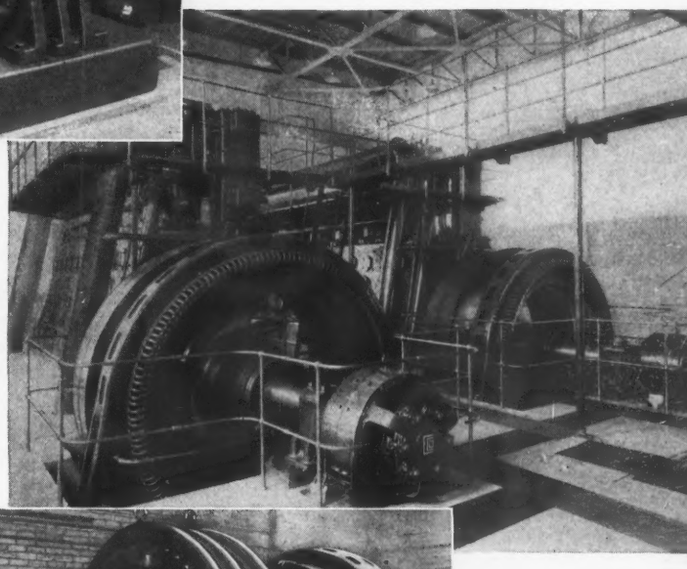
MOTORS—

At left: Elliott two-pole wound rotor and squirrel cage motors driving gasoline pumps.



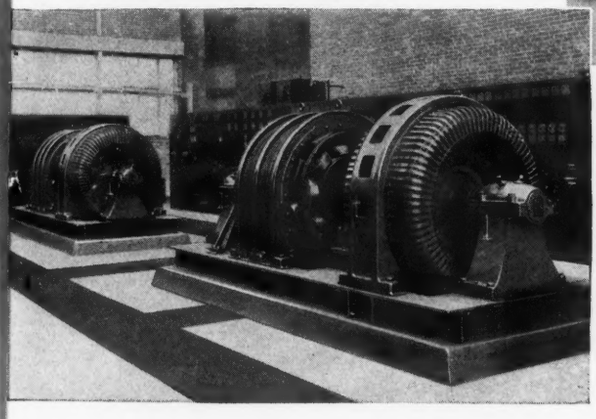
MOTORS—

At left: Elliott 1000-hp. fully compensated direct-current rolling mill drive motor.



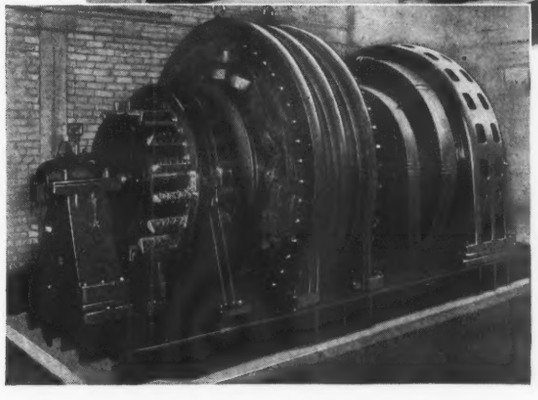
MOTOR-GENERATORS—

Below: Two Elliott 750-kw. 900-r.p.m. synchronous motor-generator sets in a steel plant.



GENERATORS—

At right: Two Elliott 1000-k.v.a. a.c. generators with direct-connected exciters, driven by Diesel engines.



MOTOR-GENERATORS—

At left: Elliott 1500-kw. motor-generator furnishing current for driving rolling mill motors.

GENERATORS to be driven by turbines, steam engines, or Diesel engines; MOTORS of all types, high or low speed, for usual or difficult applications; balanced unit MOTOR-GENERATORS; ELLIOTT designs and builds these exactly for the individual job. Properly fitted to the requirements of the drive, good machines are bound to make good records. That's the way with ELLIOTT motors and generators.

ELLIOTT motors are built specifically for the jobs they fill—and they can fill the drive job you have. Ask us.

plant equipment, remember that····

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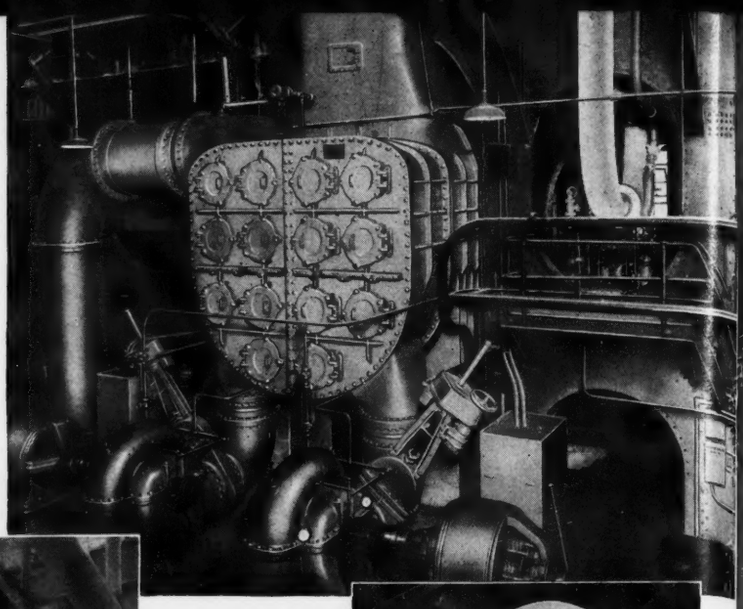
creates important savings

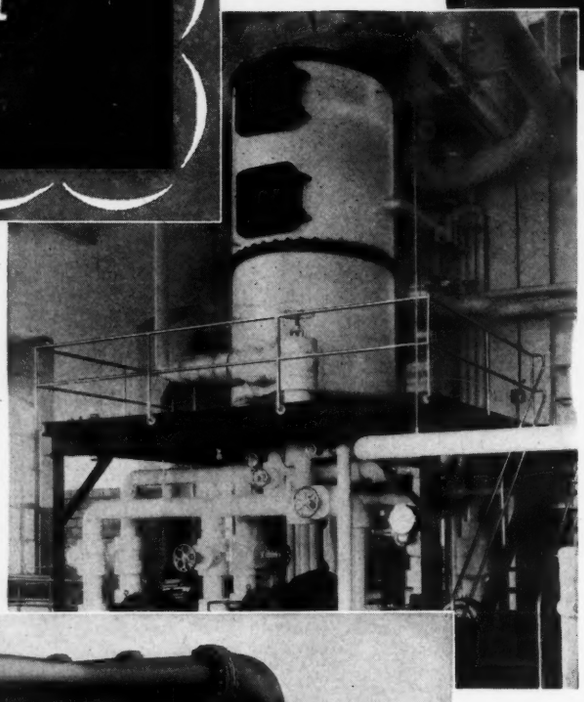
CONDENSERS

At right: Elliott 26,000-sq. ft. surface condenser serving 20,000-kw. turbine in public utility station.



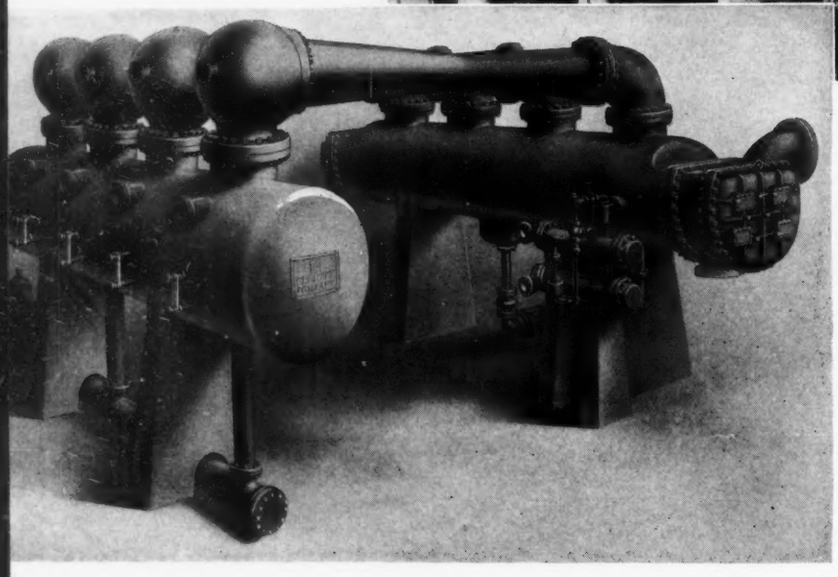
DEAERATING HEATERS—

At right: Elliott vertical deaerating heater of 250,000-lbs. per hour capacity.



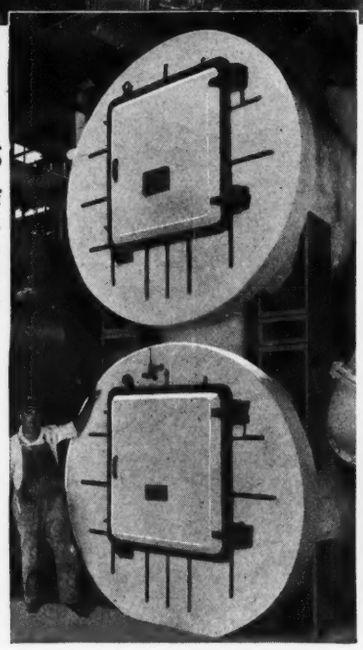
VACUUM UNITS—

Below: Elliott 300-ton vacuum refrigeration unit. One of many applications for high vacuum ejector equipment.



DEAERATORS

At right: One of two Elliott 425,000-lbs. per hour deaerators in large utility station.



CONDENSERS, FEED WATER HEATERS, DEAERATORS—these heat balance items have great possibilities in improving plant economy, when skillfully designed and applied as ELLIOTT does it. STEAM JET EJECTORS have unnumbered uses as vacuum producers in all sorts of processes from condensing and distilling to deodorizing and refrigeration.

The proper application of such equipment requires adequate engineering experience and in this, ELLIOTT is preeminent. This unparalleled experience is at your service when you call in the Elliott sales engineer.

. . . . . *Unfailing Performance is*

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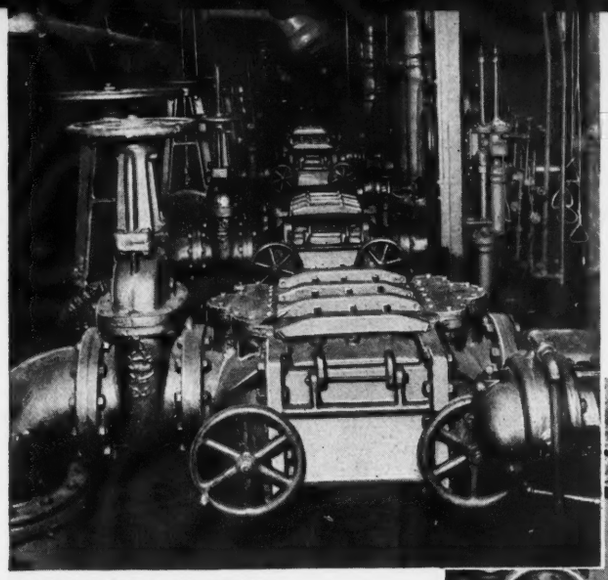

TWIN STRAINERS

At left: A line of twin strainers in a public utility plant.

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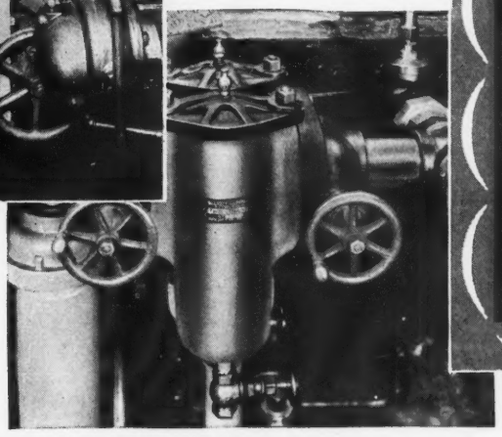
POWER PLANT ACCESSORIES

unsleeping sentinels of service

GREASE EXTRACTORS—

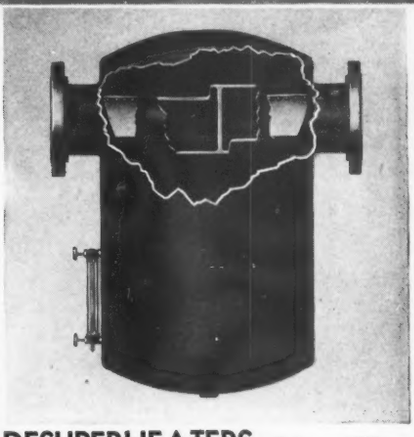
Below: Elliott grease extractors give continuous service. One side is cleaned while the other is in service.



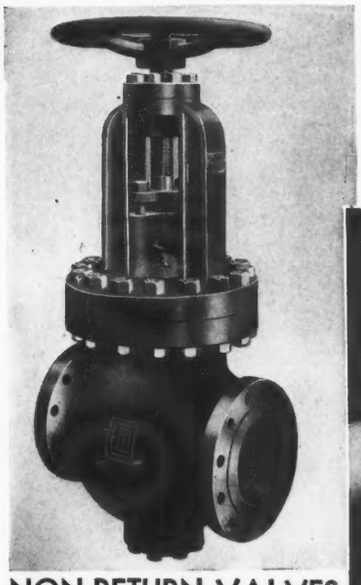
OIL STRAINERS Above: Twin oil strainer in turbine lubricating system.

SEPARATORS

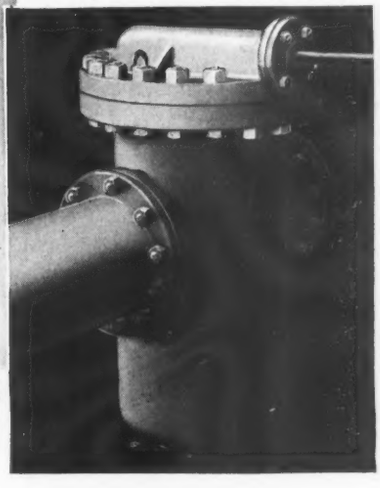
At right: Elliott Welderon receiver separator is strong and efficient.



DESUPERHEATERS Below: Elliott desuperheaters are effective and operate with safety, minimum water and regulation.



NON-RETURN VALVES
Above: Elliott non-return valves are built for all pressures and temperatures.



ELLIOTT STRAINERS, FILTERS, NON-RETURN VALVES, SEPARATORS—privates in the ranks of power plant equipment on which you can depend to attain and hold the objective of a smooth-running plant. They effectively guard you against trouble and interruptions to service. They have well earned their present popularity by service records extending over 25 years. ELLIOTT DESUPERHEATERS convert superheated to saturated steam or lower the temperature of superheat to any desired amount—surely and efficiently.

Assure the dependability of your plant with ELLIOTT ACCESSORY EQUIPMENT.

Characteristically Elliott . . . . . .

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Rich in Experience

CROSBY

is ready for TOMORROW'S needs

The part Crosby valves and gages can play in reducing operating costs and increasing efficiency and security in your plant today is the logical result of the improvements made during the past years. Noteworthy in their developments are

Incorporated

1876

in 1889

at the Paris Exposition, Crosby equipment established a world-wide reputation.

in 1893

at the Columbian Exposition, Crosby products again received highest awards.

in 1895

at the Cotton States and International Exposition at Atlanta, further awards were bestowed upon Crosby Indicators, Valves and Gages.

in 1896

at the Russian Exposition at Nijni-Novgorod, Crosby specialties again sustained their international reputation for dependability and quality.

in 1905

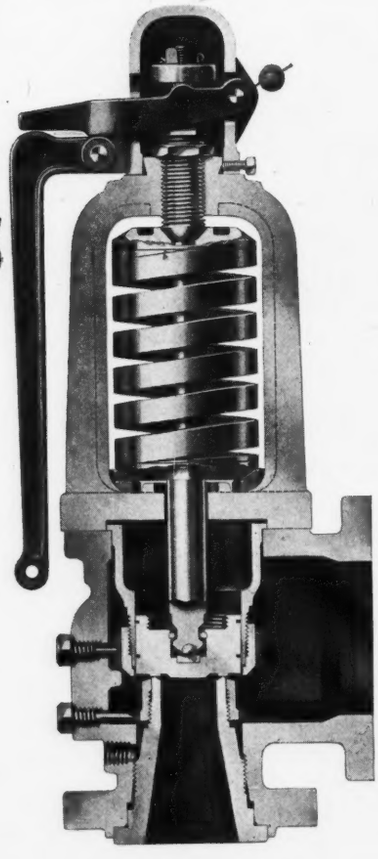
Crosby equipment received the Grand Prize at the Louisiana Purchase Exposition.

CROSBY EQUIPMENT

Pop safety valves, relief valves, fullway valves; indicating and recording gages; gage testers, indicators; globe, angle and check valves, chime whistles, whistle valves, gage boards.

CROSBY NOZZLE SAFETY VALVES

For TODAY'S Station Operation



This new Safety Valve has been designed especially to meet the demands of today—and tomorrow—of modern central stations. The large number of these valves in service have proved efficient under the most exacting service conditions.

There is no "warn" and no simmering, because a two-stage valve disc lift gives such smooth, shockless operation that perfect seat contact is preserved indefinitely. Discs and seats are of forged alloy steel of such design that they do not warp, nor are they affected by valve body expansion.

Upon request we will gladly have our representative call and tell you why so many engineers prefer Crosby Nozzle Safety Valves.

And gages. High pressure steam gage—double tube type, 6 to 16 inches, pressures 100 to 1500 pounds; steel tube gages for indicating pressures at high temperatures with test gage accuracy; recording gages for steam, gas, air, water, ammonia, etc.

ADVANTAGES

1. Built for any pressure and temperature.
2. Actual relieving capacity 98% of a free orifice.
3. Forged alloy steel nozzle. No threads under pressure.
4. Symmetrical forged alloy valve disc or nozzle cannot warp.
5. No guide vanes. Valve disc guided externally and from above.
6. Extra adjusting ring provides micrometrically exact adjustment easily made without dismantling valve.
7. Valve seat easily maintained.
8. Even disc loading eliminates "warn."
9. Spring air-cooled and under very low stress.
10. Maintenance negligible.

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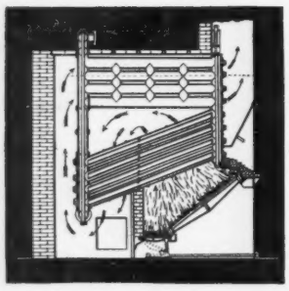
Boston, Mass.

STEAM POWER *for a* NEW INDUSTRIAL WORLD

Born of experience covering the entire history of modern steam generation and use

BABCOCK & WILCOX EQUIPMENT

is today complete in every important respect

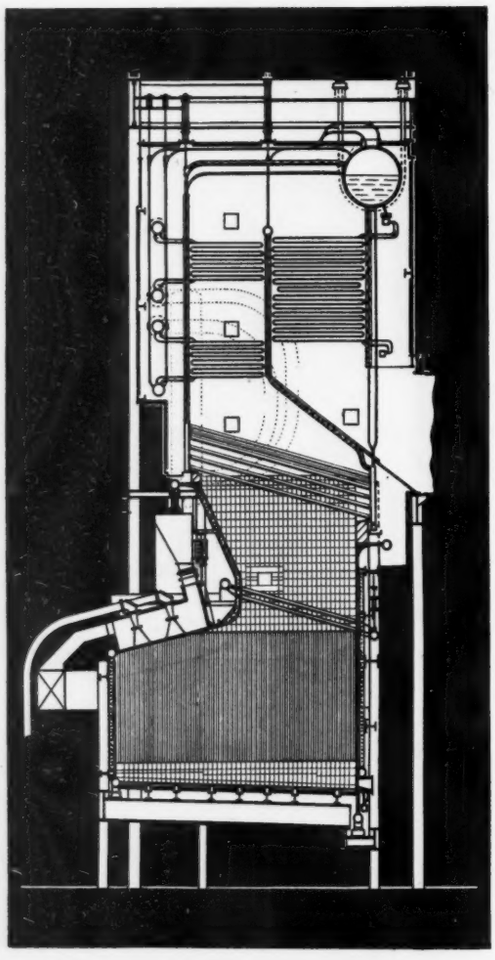


1867

THE FIRST B&W BOILER

In this year, the patent for the original Babcock & Wilcox Water-Tube Boiler was granted to George H. Babcock and Stephen Wilcox, and the partnership of Babcock, Wilcox & Company was formed. The boiler was offered for sale as the Babcock & Wilcox Patent Non-Explosive Steam Boiler, and at a time when cheaper shell-boilers were standard for all services.

OVER FIFTY YEARS OF LEADERSHIP IN

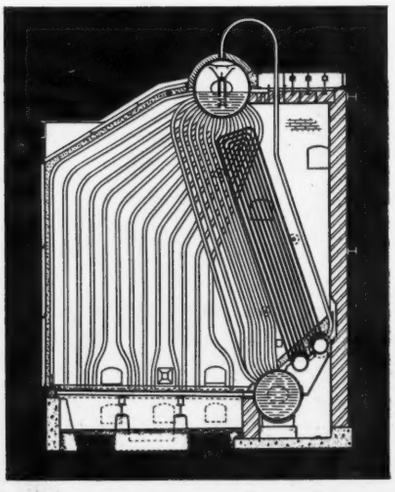


Complete B&W

In the entire range of steam-generating service, there is no combination of conditions, involving capacity, pressure, temperature, space, fuels, or load characteristics that cannot be best met, economically and with complete assurance of continued satisfaction, by some type of boiler made by The Babcock & Wilcox Company.

The B&W Sectional Header, the Stirling Bent-Tube, and the Type H Stirling Boilers are those used, world over, for power-plant service at capacities ranging fram 1500 to over 1,000,000 pounds of steam per hour and at pressures up to 2500 pounds per square inch.

The range of service covered by Babcock & Wilcox Boilers has been recently extended by the development of the B&W Integral-Furnace Boiler, a completely coordinated unit that includes boiler, superheater, water-cooled furnace, fuel-burning and control equipment. These units are avail-



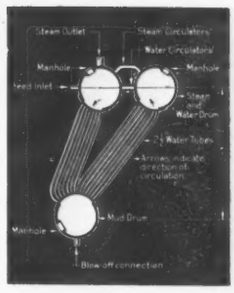
Above . . . typical Babcock & Wilcox Boiler Unit consisting of a B&W Boiler with Babcock & Wilcox Superheater, Desuperheater, Economizer, Bailey Water-Cooled Slag-Tap Furnace, and Multiple-Intertube Burners for firing pulverized coal. At the right . . . a sectional front view of the latest complete unit built by The Babcock & Wilcox Company . . . the B&W Integral-Furnace Boiler which includes Boiler, Superheater, Water-Cooled Furnace, and complete Fuel-Burning and Control Equipment.

THE BABCOCK &

1889

THE FIRST STIRLING BOILER

Since 1889, when the first Stirling Bent-Tube Boiler was built, and 1906, when the Stirling Consolidated Boiler Company and its plant at Barberton, Ohio were acquired by The Babcock & Wilcox Company, the design of the StirlingBoiler has been progressively improved to meet changing feed-water conditions and the demand for higher pressures, temperatures, ratings, and capacities.

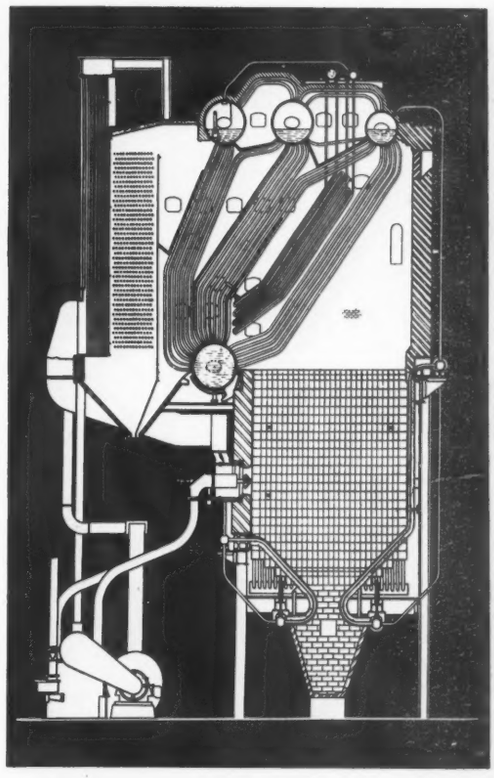


Boiler Units . . .

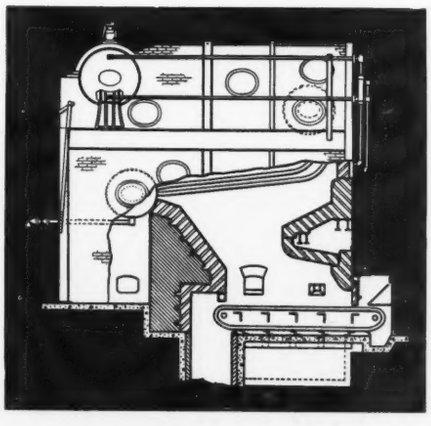
able in small and moderate sizes, for pressures up to 650 pounds per square inch, and utilizing pulverized-coal, oil, or gas, either singly or in any combination.

Furthermore, The Babcock & Wilcox Company is prepared to build boilers of standard and special design for waste-heat, or for diphenyl, mercury, and other heat-transfer mediums.

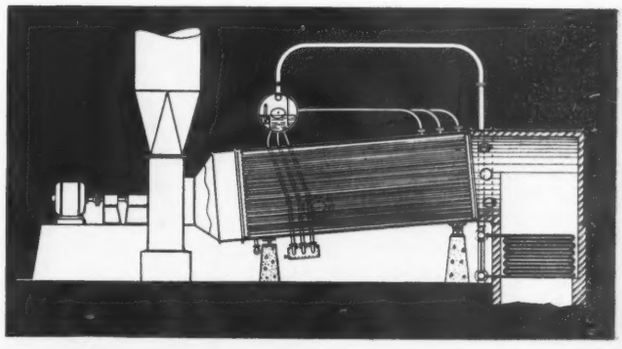
With such a diversified and comprehensive range of types and sizes of boilers, and with its experience accumulated during 67 years in the building of boilers, and in world-wide installations totaling over 300,000,000 sq. ft. of heating surface, The Babcock & Wilcox Company is in an excellent position to design equipment for new plants, as well as to give dependable and unprejudiced advice regarding the modernization and rehabilitation of old or obsolescent steam power plants. Inquiries are invited.

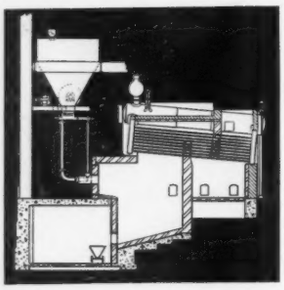


A complete Stirling Boiler Unit with Babcock & Wilcox Superheater, Return-Bend Economizer, Air Heater, Bailey Water-Cooled Hopper-Bottom Furnace, and Coal Pulverizing and Burning Equipment.



At the left . . . a Babcock & Wilcox Type H Stirling Boiler and Chain-Grate Stoker arranged for forced-blast operation with anthracite. At the right . . . a typical arrangement of the Babcock & Wilcox Gas-Tube Waste-Heat Boiler.





1916

THE FIRST PULVERIZED-COAL FIRING

The experience of The Babcock & Wilcox Company in pulverized-coal firing started with the pioneering activities of the Fuller Lehigh Company in the cement industry in 1904. The earliest application of this method of firing to power boilers was that of a bin system, in 1916, to eight 250 h.p. boilers in the shop of a mid-western railroad. The direct-fired system was developed after this company was acquired by The Babcock & Wilcox Company in 1926, and provides a simple and safe method of realizing the full advantages of pulverized-coal firing at a minimum cost.

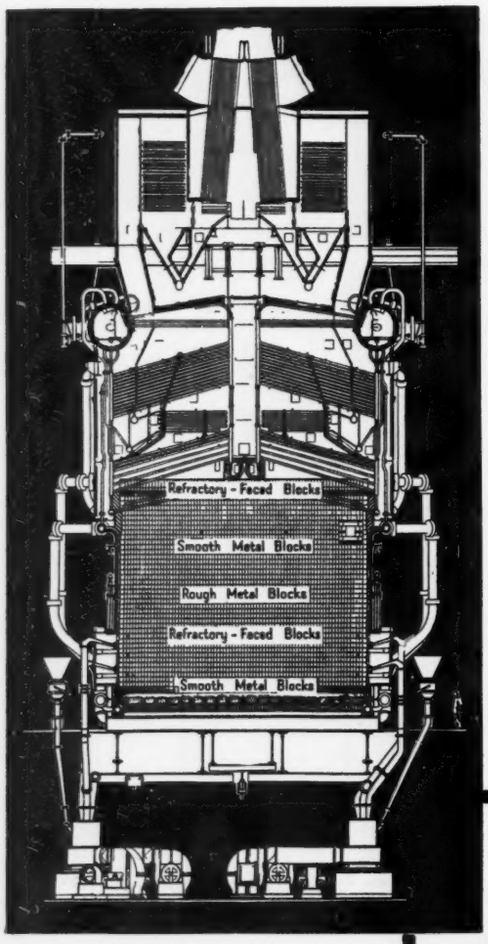
OVER FIFTY YEARS OF LEADERSHIP IN

Complete Furnace

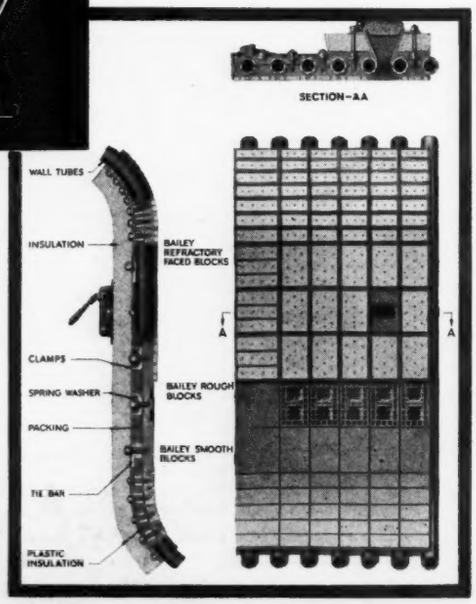
Babcock & Wilcox service to industry has not been and is not confined to the fabrication and installation of boilers. It has extended far beyond, and has resulted in the development of furnace constructions and other component equipment for complete units.

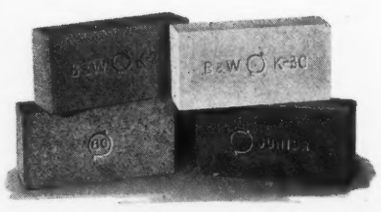
These furnace constructions include such widely-used types as the hopper-bottom and the slag-tap for pulverized-coal firing, as well as other extensively-used designs for oil- and stoker-fired boilers.

Greater in importance, however, is the exceptionally wide variety of surfaces made available, including three general types of Bailey Blocks, and two kinds of Stud-Tube Wall for water-cooled furnaces, as well as two grades of firebrick for solid refractory surfaces, and an insulating firebrick sectionally supported wall of light weight.



Above . . . twin B&W Boiler with Babcock & Wilcox Interdeck Superheater, Economizer, Air Heater, and Pulverized Coal Equipment for firing a Bailey Water-Cooled Slag Tap Furnace. At the right . . . a section of Bailey Water-Cooled Furnace Construction with refractory faced, smooth and rough bare-metal blocks.



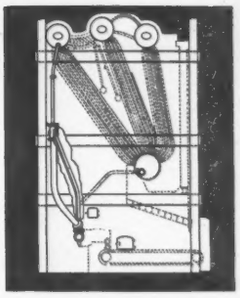


B & W Firebrick

THE BABCOCK &

1924
THE FIRST BAILEY WATER-COOLED FURNACE

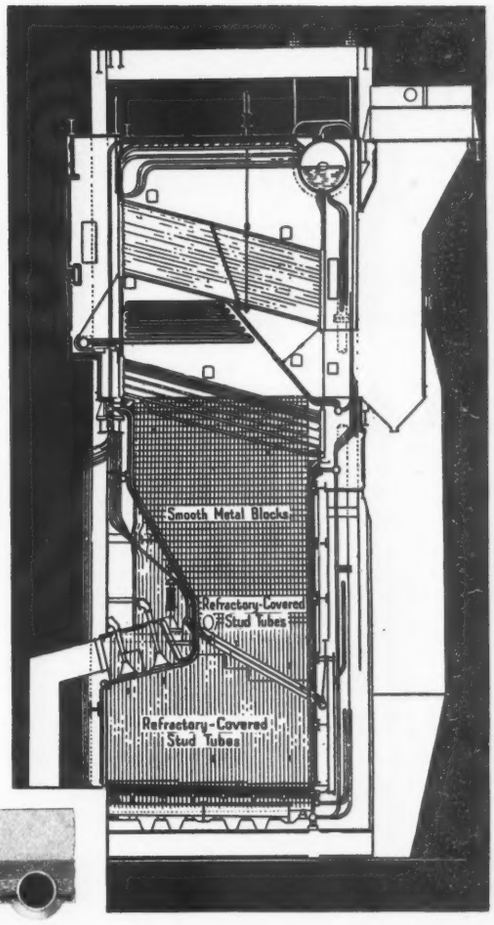
Introduced in 1924 with the application of 175 square feet of surface in the rear wall of a stoker-fired central-station boiler, Bailey Water-Cooled Furnace Construction has since been applied to boilers in practically every country in the world. The original Bailey Block construction has been supplemented by the Stud-Tube construction, whereby the range of furnace conditions that can be economically met has been extended.



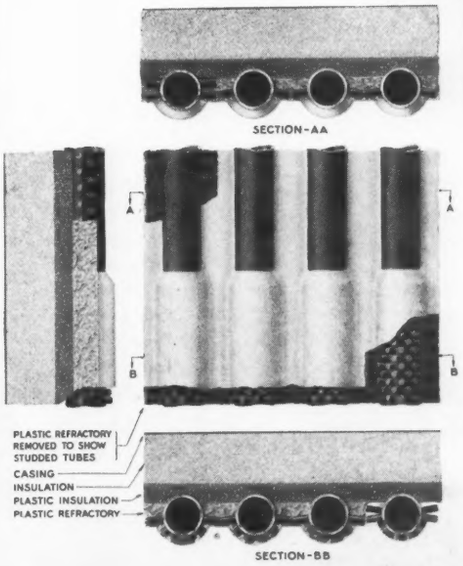
Constructions . . .

Furnaces of these constructions are used with all kinds of fuels fired in every commercial manner. They are particularly advantageous for the burning of all classes of coal, from anthracite to lignite, covering wide ranges of moisture, volatile, sulphur, and ash content, as well as ash fusing temperatures.

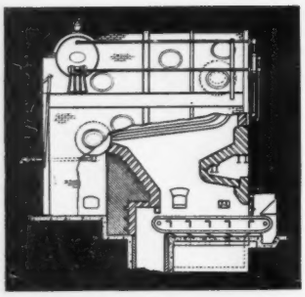
Of the companies providing furnace materials or furnace constructions, The Babcock & Wilcox Company can best meet this entire range of conditions. The practical application of the water-cooled furnace constructions is shown by world-wide installations having a total capacity of more than 118,000,000 pounds of steam per hour and ranging in service from a lignite-burning stand-by unit in a hydro-electric plant in New Zealand, or in an industrial plant in Russia, to units in typical high load-factor central stations in the United States.



B & W Mortars and Plastics



Above . . . B & W Boiler with Babcock & Wilcox Interdeck Superheater and Multiple Intertube Burners for firing a Bailey Water-Cooled Slag-Tap Furnace . . . At the left . . . a section of Bailey Stud-Tube Construction showing full-studded and partially-studded water-cooled furnace construction.



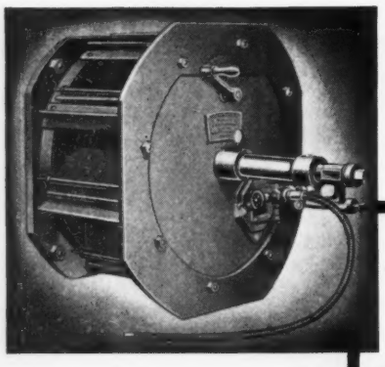
1929

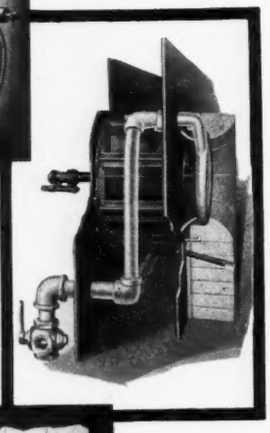
THE FIRST TYPE H STIRLING BOILER

Conforming to its policy of providing steam-generating equipment for all service, The Babcock & Wilcox Company developed the Type H Boiler in 1928, making the first installation in 1929. This boiler is especially applicable where headroom and floor space are limited and particularly for industrial power, heating, and process plants of small and moderate sizes. The success attained by this boiler is indicated by the fact that, to date, installations totaling over 1,500,000 sq. ft. of heating surface have been made.

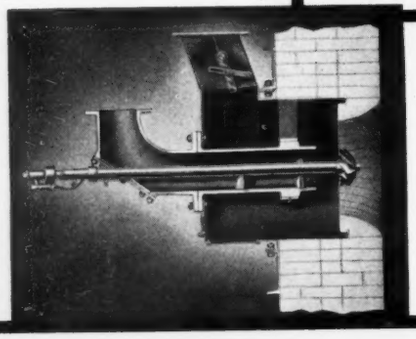
OVER FIFTY YEARS OF LEADERSHIP IN

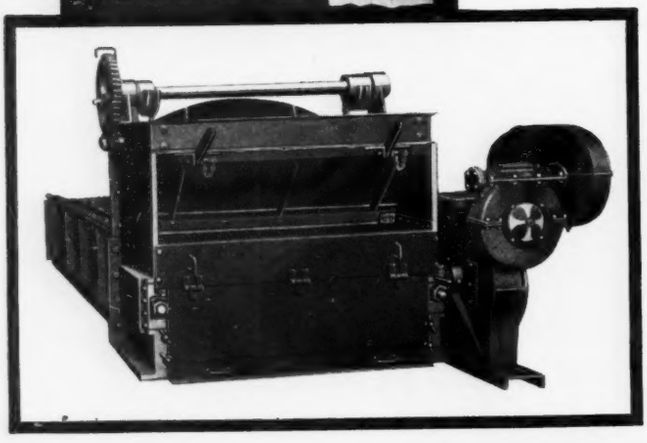
Complete Fuel-Burning Equipment



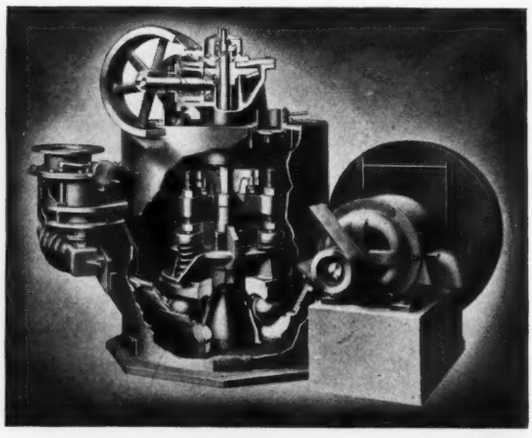


Above . . . B&W Mechanical Atomizing Oil Burner for natural or induced draft. At the right . . . the B&W Combination Oil-and-Gas Burner. Below . . . B&W Circular Pulverized-Coal Burner.





The view at the left shows the Standard Type Stoker, while that at the right features the Type B Pulverizer for small capacities.

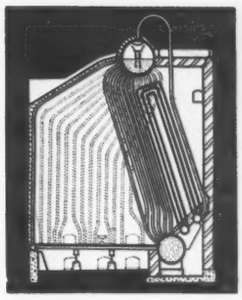


The Babcock & Wilcox Company is in an excellent position to advise on and to provide fuel-burning equipment, having unparalleled experience in the field of combustion and a range of equipment offered by no one other boiler manufacturer.

In addition to pulverized-coal equipment, oil burners, and chain-grate stokers, the Company has equipment for, and has had experience in, burning such fuels as black liquor, soda bottoms, acid sludge, and other combustible residuals of process industries. Further developments of the Company in the field of fuel burning are combination burners for pulverized coal, oil, and gas, whereby these fuels may be burned singly or in any combination, making practicable conversions from any fuel or combinations of fuels to others with resultant economies.

THE BABCOCK & WILCOX COMPANY

1933
THE FIRST
INTEGRAL-FURNACE BOILER



To provide the advantages of pulverized-coal firing for industrial plants of small and moderate capacities, The Babcock & Wilcox Company, in 1933, again evidenced its leadership in the field of steam-generation by introducing the Babcock & Wilcox Integral-Furnace Boiler, complete with suitable component equipment. This unit is equally adapted to oil or gas firing, utilizing the three fuels singly or in any combination.

THE DEVELOPMENT OF STEAM POWER

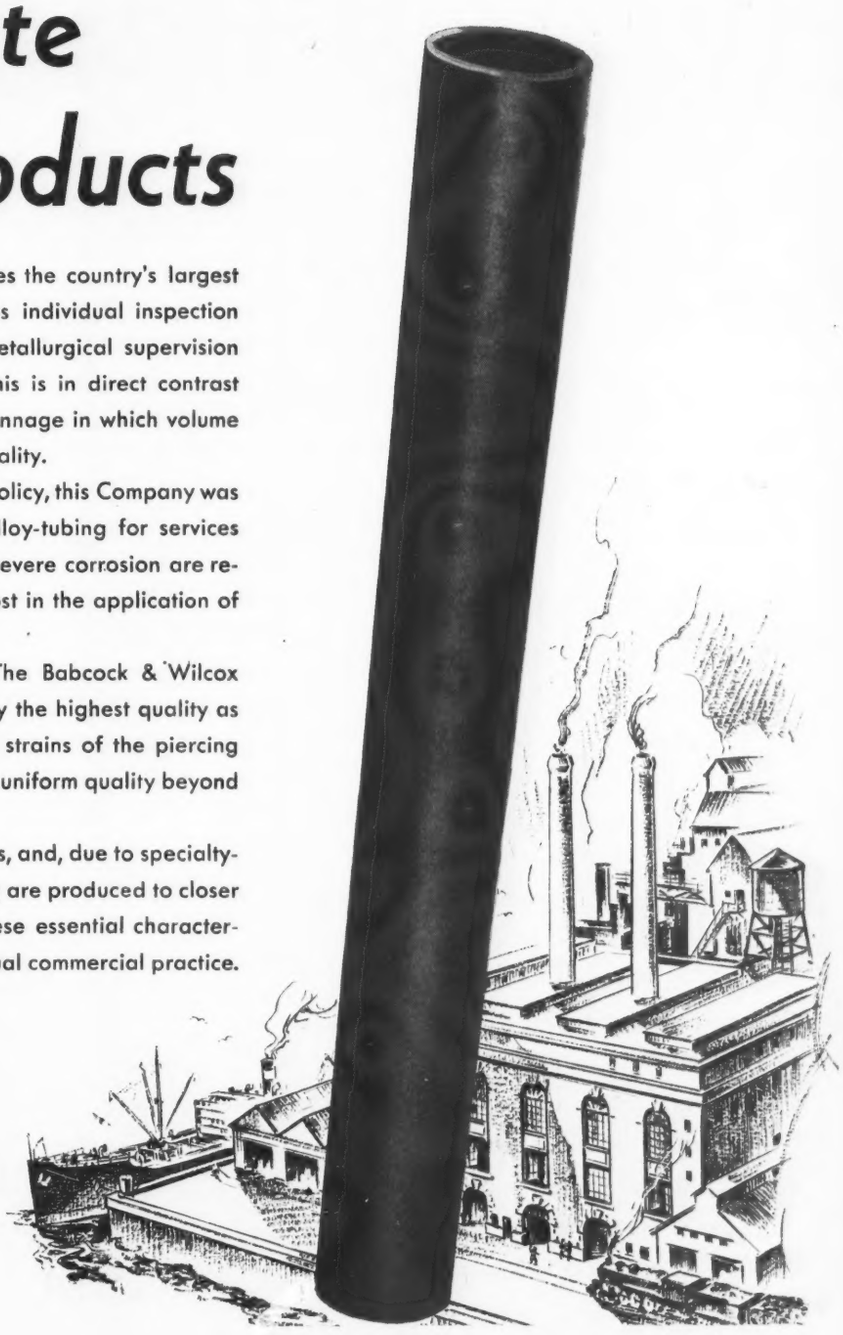
Complete Tubular Products

The Babcock & Wilcox Tube Company operates the country's largest specialty tube-mill wherein each tube receives individual inspection and is manufactured with all the care and metallurgical supervision requisite to the production of quality tubes. This is in direct contrast with the quantity production of mainly pipe tonnage in which volume of output necessarily takes precedence over quality.

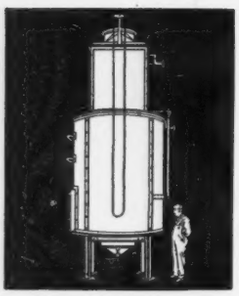
In keeping with its specialty-mill operating-policy, this Company was the first in this country to produce seamless alloy-tubing for services in which resistance to high temperatures and severe corrosion are required. The Company continues to be foremost in the application of new alloys to special services.

The seamless pipe and tubing made by The Babcock & Wilcox Tube Company are pierced from billets of only the highest quality as ordinary steel will not withstand the torsional strains of the piercing process, which automatically sets a standard of uniform quality beyond which ordinary steel cannot pass.

There is no weld or line of possible weakness, and, due to specialty-mill standards, B&W Seamless Pipe and Tubing are produced to closer tolerances, have a finer finish, and possess these essential characteristics to a more uniform degree than is the usual commercial practice.



THE BABCOCK & WILCOX TUBE COMPANY



BOILERS FOR THE FUTURE

That The Babcock & Wilcox Company is well prepared to meet future requirements of higher pressures, temperatures, ratings and capacities in the generation of steam is indicated by the fact that the Company has already installed more boilers for operation at or above 1200 lb. pressure than the combined totals of all other manufacturers in the world, and has had operating experience with boilers built for 3500 lb. pressure.

THE B & W FUSION-WELDING PROCESS

Welding Leadership

The Babcock & Wilcox Company was the first of all boiler manufacturers to study, develop, and apply a fusion-welding process to the fabrication of boiler drums.

This B&W Fusion-Welding Process is the result of a research program that was started early in 1926 and was extremely comprehensive in the methods of welding used, the type of vessels welded, and in the range and severity of the tests made to prove the quality of the welds.

The results of this study and subsequent development were so impressive that, since 1930, when the first fusion-welded boiler drum was placed in service, more than 1400 boiler drums fusion-welded by Babcock & Wilcox have been installed.

Further recognition of the excellence of this process and an endorsement of the highest character was the award to The Babcock & Wilcox Company of the contract for the fabrication of approximately 45,000 tons of plate-steel pipe for Boulder Dam.

and a nation-wide organization for service

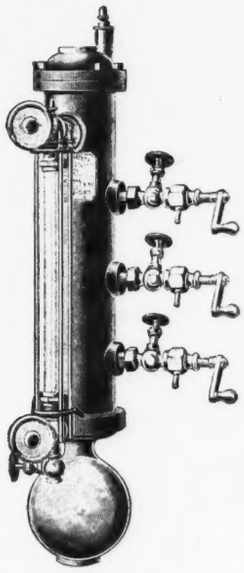
ATLANTA.....Candler Building
BOSTON.....49 Federal Street
CHICAGO.20 North Wacker Drive
CINCINNATI.....Carew Tower
CLEVELAND ...Guardian Building
DALLAS, TEXAS
Magnolia Building
DENVER....444 Seventeenth Street
DETROIT.....Ford Building
GALVESTON, TEXAS
Security Building
HOUSTON, TEXAS..Electric Bldg.
LOS ANGELES ...Edison Building
NEW ORLEANS..344 Camp Street
NEW YORK .....85 Liberty Street
PHILADELPHIA..Packard Building
PHOENIX, ARIZ.....Luhr's Tower
PITTSBURGH.....Koppers Building
PORTLAND, ORE....Failing Bldg.
SALT LAKE CITY..Kearns Building
SAN ANTONIO, TEXAS
Gibbs Building
SAN FRANCISCO
450 Mission Street
SEATTLE.....Smith Tower
TULSA, OKLA., Thompson Building

THE BABCOCK & WILCOX COMPANY

FOR HALF A CENTURY

WE'VE KEPT THE WHISTLE ON BOILER WATER LEVELS

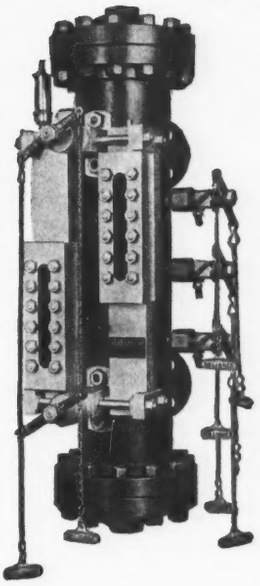
In 1884



This quaint device was a Reliance Low and High Water Boiler Alarm of 50 years ago, good for pressures all the way up to 60 pounds. But in spite of its curious gage cocks, it worked — every time.

1884-1934 Reliance 50 YEARS OF SAFETY

In 1934



Today's Reliance Forged Steel Boiler Alarm No. 7-850, good for pressures to 850 pounds, equipped with water gage and gage cocks for 2000 pounds pressure. Half a century of real progress.

In 50 years Engineers have put more than

125,000

Reliance Safety Water Columns on their boilers — without a single case of failure in an emergency.

RELIANCE SAFETY WATER COLUMN

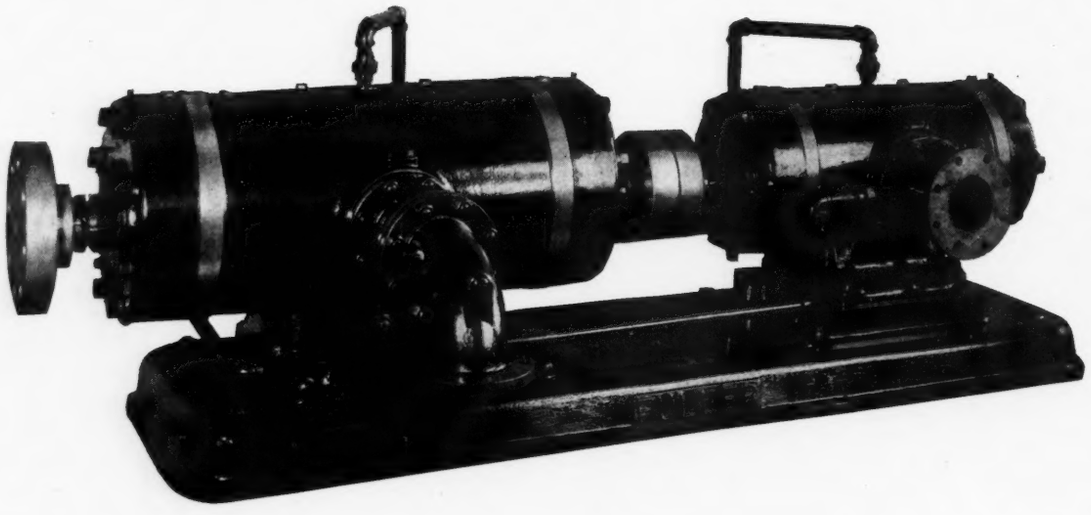
TRADE MARK REG. IN U.S. PAT. OFF.

Reliance

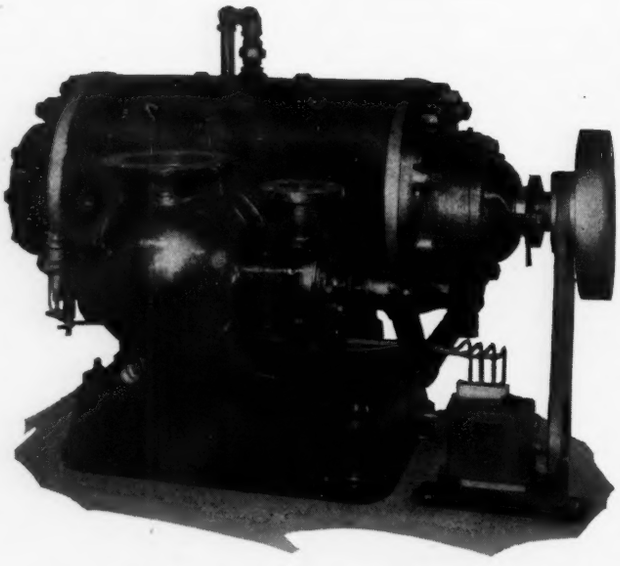
SAFETY WATER COLUMNS

The Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland, O.

HERE IS AN AIR COMPRESSOR FOR CONTINUOUS SERVICE » »



Two-stage Fuller Rotary Compressor



The intake regulator side of a single-stage compressor of similar capacity.

Fuller Rotary Compressors and Vacuum Pumps have fewer moving parts than any other machines for similar service. This mechanical simplicity, together with correct design and precise construction has contributed to their enviable records of long, continuous operation, without maintenance annoyances. They are of the multi-vane type.

The roller-bearing mounted rotor and its radially sliding vanes or blades are the only moving parts. The drive is direct, there are no valves or bearings requiring adjustment. These machines deliver a steady flow of air, free from pulsation, and maintain their efficiency throughout their long life. Their operation is entirely vibrationless.

Weight and size are the conspicuous features of Fuller Compressors. Single and two-stage machines weigh only a half to a third as much, and occupy about one-third of the floor space required for conventional units of equivalent capacity.

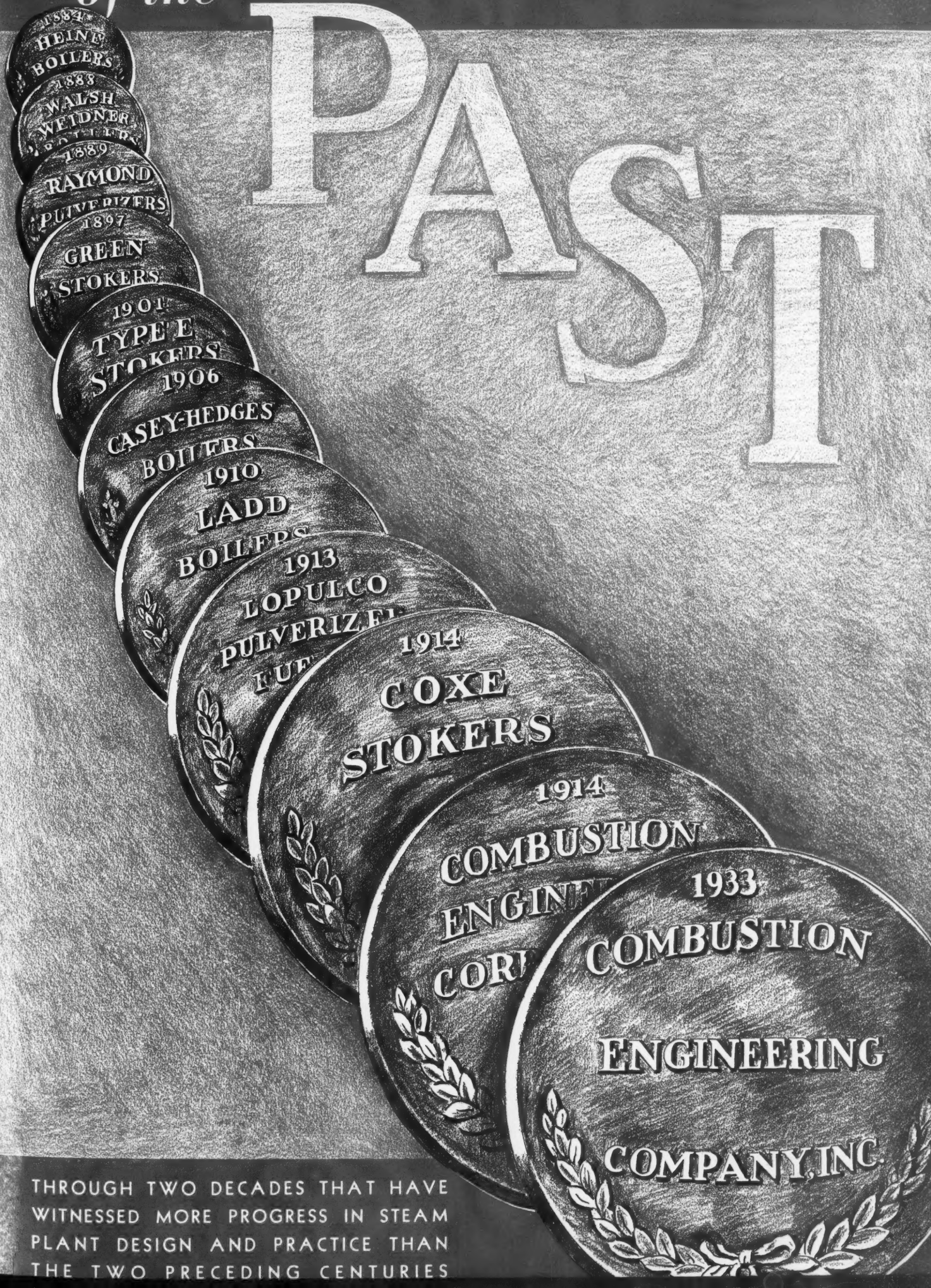
The same machine may be used alternately in vacuum and pressure service, and the change can be made merely by opening two and closing two valves in the lines.

CHICAGO: 1118 Marquette Bldg.

Fuller Company

CATASAUQUA, PENNA. U. S. A.

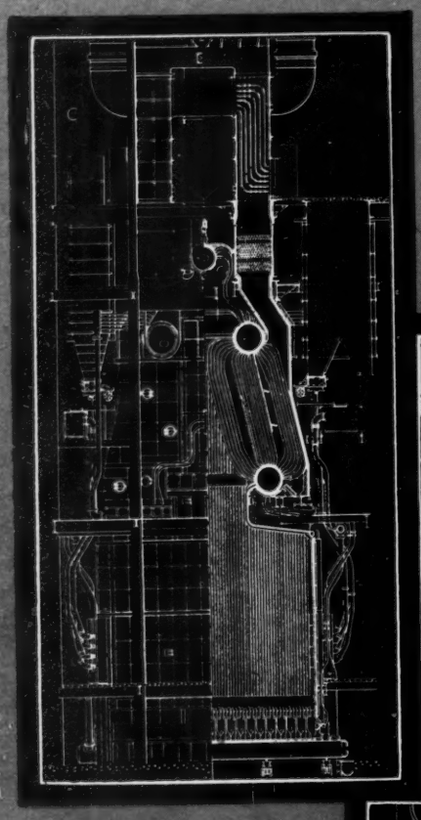
DEEP ROOTED *in the experience of the* PAST



THROUGH TWO DECADES THAT HAVE WITNESSED MORE PROGRESS IN STEAM PLANT DESIGN AND PRACTICE THAN THE TWO PRECEDING CENTURIES

NOTABLE CONTRIBUTIONS

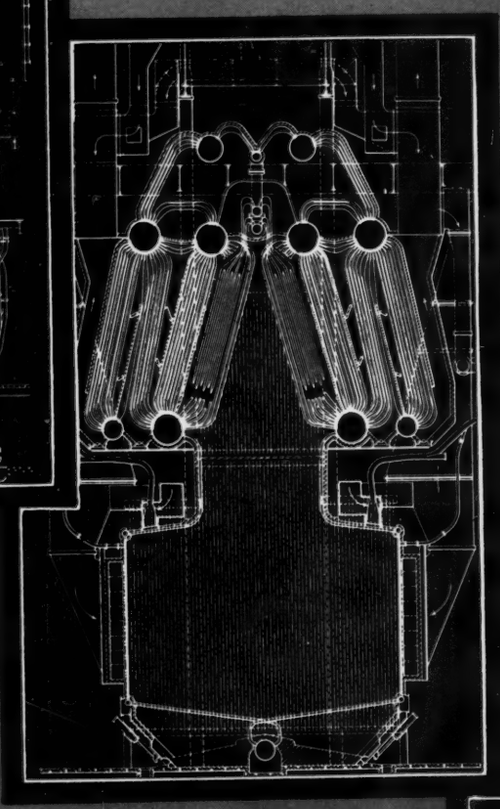
PRE



Highest Sustained Boiler Output

Complete C-E unit at Kips Bay Station, New York Steam Corporation. Has averaged over 805,000 lb. of steam per hr. for one month.

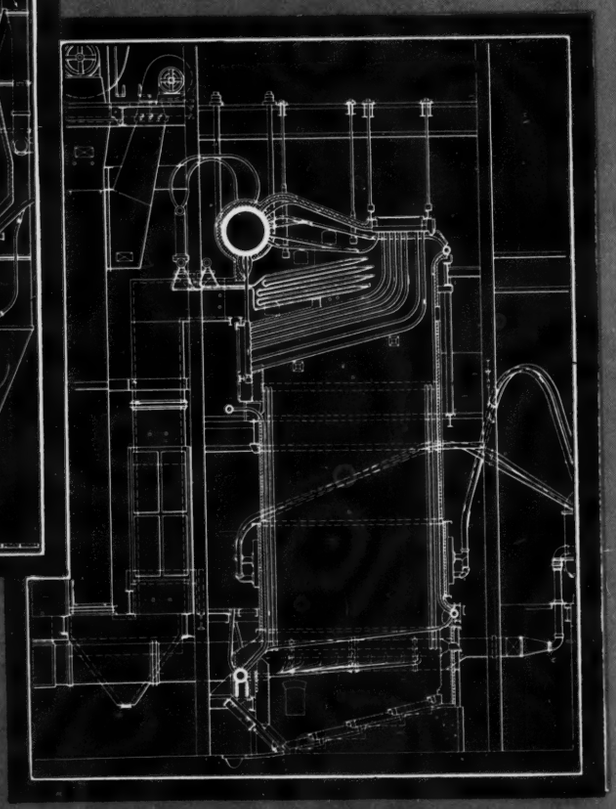
Over 1,100,000 boiler hp. equipped with C-E pulverized fuel systems



Largest Boilers in the World

Three complete C-E units, East River Station, New York Edison Company. Have been operated at rate of 1,270,000 lb. of steam per hr.

Nearly 4,000,000 boiler hp. equipped with C-E Stokers



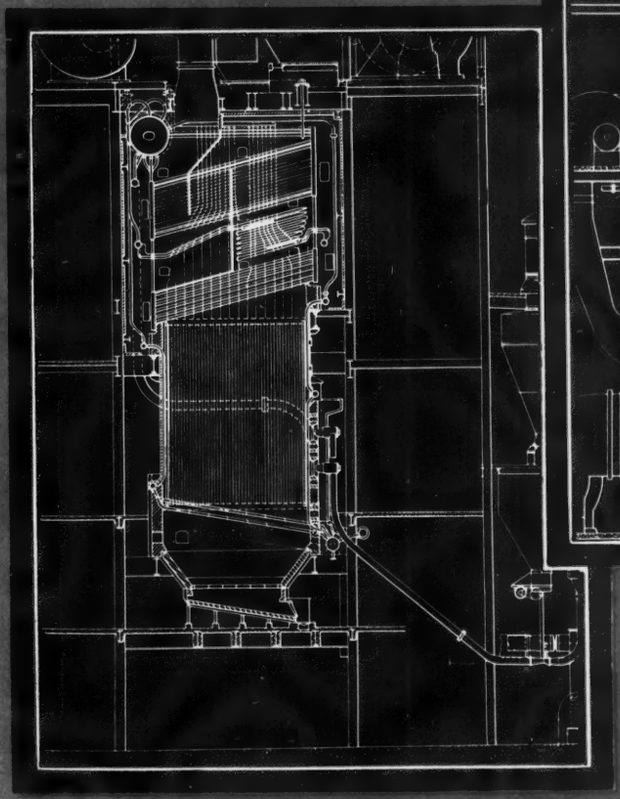
Highest Pressure Boilers in Commercial Operation in America

Two complete C-E units, Lockland, Ohio, plant, Philip Carey Company. Pressure—1800 lb.

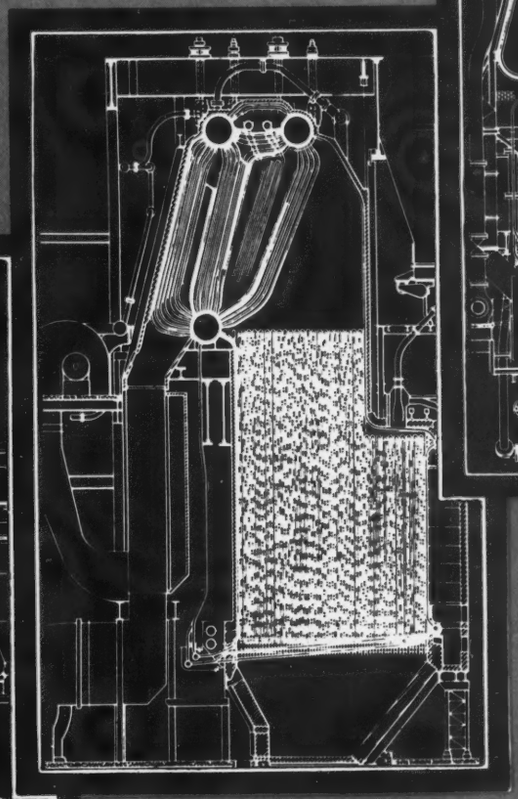
In the largest power stations and in thousands C-E equipment has contributed to

TO THE PROGRESS OF THE SENT

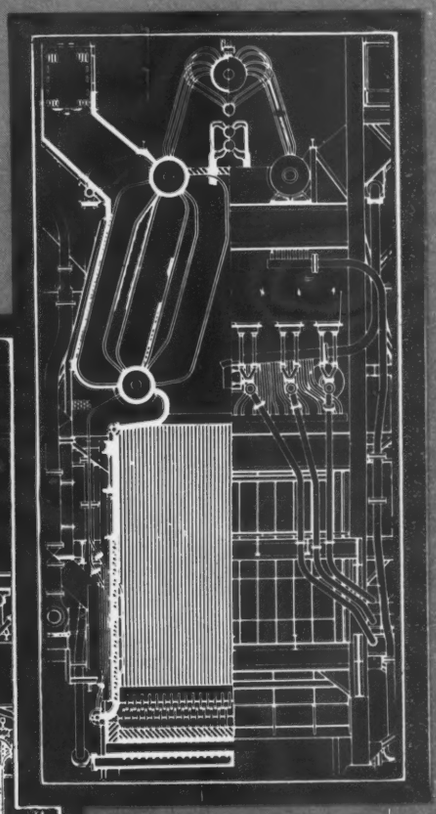
Nearly 700,000 boiler hp. equipped with C-E water walls



Largest Single-Set Sectional Header Boiler
Complete C-E unit at Burlington Station, Public Service Electric & Gas Company of New Jersey. Pressure—730 lb. Has operated at rate of 625,000 lb. of steam per hr.



Largest High-Pressure Central Station Boiler
Complete C-E unit now under construction at East Port Washington Station, The Milwaukee Electric Railway & Light Company. Pressure—1390 lb. Expected capacity—700,000 lb. of steam per hr.



Largest High-Pressure Industrial Plant Boilers
Two complete C-E units, Rouge Plant, Ford Motor Company. Pressure—1400 lb. Have been operated at rate of 750,000 lb. of steam per hr.

Over 6,000,000 sq. ft. of C-E air heater surface

of medium-sized and small industrial plants higher performance standards

COMBUSTION ENGINEERING believes that fuel-generated steam will continue to be the most extensively used medium for supplying heat and power, and that five years hence the designs of the necessary equipment—boilers, furnaces, stokers, pulverizers, burners and heat recovery apparatus—will be appreciably better than they are today. It purposes to play a leading part not only in effecting improved equipment designs but also in contributing to better applications of equipment and better operating practice.

That this viewpoint is practical rather than idealistic is evidenced by the fact that C-E engineers are now engaged in extensive design studies of virtually all the company's products with instructions to effect improvements wherever possible.

Much stress is laid on design refinement since, no matter how meritorious present designs may be, further improvement is always possible and is essential to the progress that equipment users seek and have the right to expect.

Progressively alert to the possibilities of the

FUTURE

C-E PRODUCTS

BOILERS

C-E Sectional Header Boiler
C-E Box Header Boilers
C-E Bent Tube Boilers
C-E H.R.T. Boilers
C-E Electric Boilers
C-E Marine Boilers

STOKERS

C-E Multiple Retort Stoker
Type E Underfeed Stoker
C-E Stoker-Unit *(for small boilers)*
Type H Stoker *(for industrial furnaces)*
Coxe Traveling Grate Stoker
Green Chain Grate Stoker *(natural draft)*
Green Chain Grate Stoker *(forced draft)*

PULVERIZED FUEL SYSTEMS

(for boilers and industrial furnaces)
C-E Storage System
C-E Direct-Fired System
Raymond Pulverizing Mills

WATER-COOLED FURNACES

C-E Water-Cooled Furnace
C-E Water Screen
C-E Slagging Furnace

COMPLETE UNITS

Combustion Steam Generator *(a unit of standardized overall design)*
Coordinated designs comprising any combination of boiler and firing equipment

OTHER EQUIPMENT

C-E Air Preheaters *(plate and tubular types)*
C-E Economizers
C-E Oil Burners
Grieve Grates
C-E Ash Conveyors
C-E Ash Hopper

FABRICATED PRODUCTS

(riveted or welded fabrication—carbon or alloy steels)

C-E

COMBUSTION ENGINEERING COMPANY, INC.

200 Madison Avenue, New York • Offices in Principal Cities • Canadian Associates, Combustion Engineering Corporation, Ltd., Montreal

A-147

Every well established type of fuel burning and boiler equipment exists for logical reasons. It meets certain fuel conditions or service requirements better than any other type. Combustion Engineering, with its complete line of equipment, is in a position to make recommendations based solely on the conditions and requirements of each particular plant.

Confidence in another man's virtue is no slight evidence of a man's own.

Montaigne

PUBLISHED IN the interest of adherence to principles in buying and selling that beget confidence, by The Superheater Company and The Air Preheater Corporation, 60 East 42nd Street, New York, which believe that business transactions conducted on horsetrading principles bring profit to neither party. On terms of mutual confidence, mutual profit results.

Since our companies, through strict adherence to ethical business procedure, prospered on their 1933 transactions, our customers have been afforded full measure of the service upon which confidence is built.

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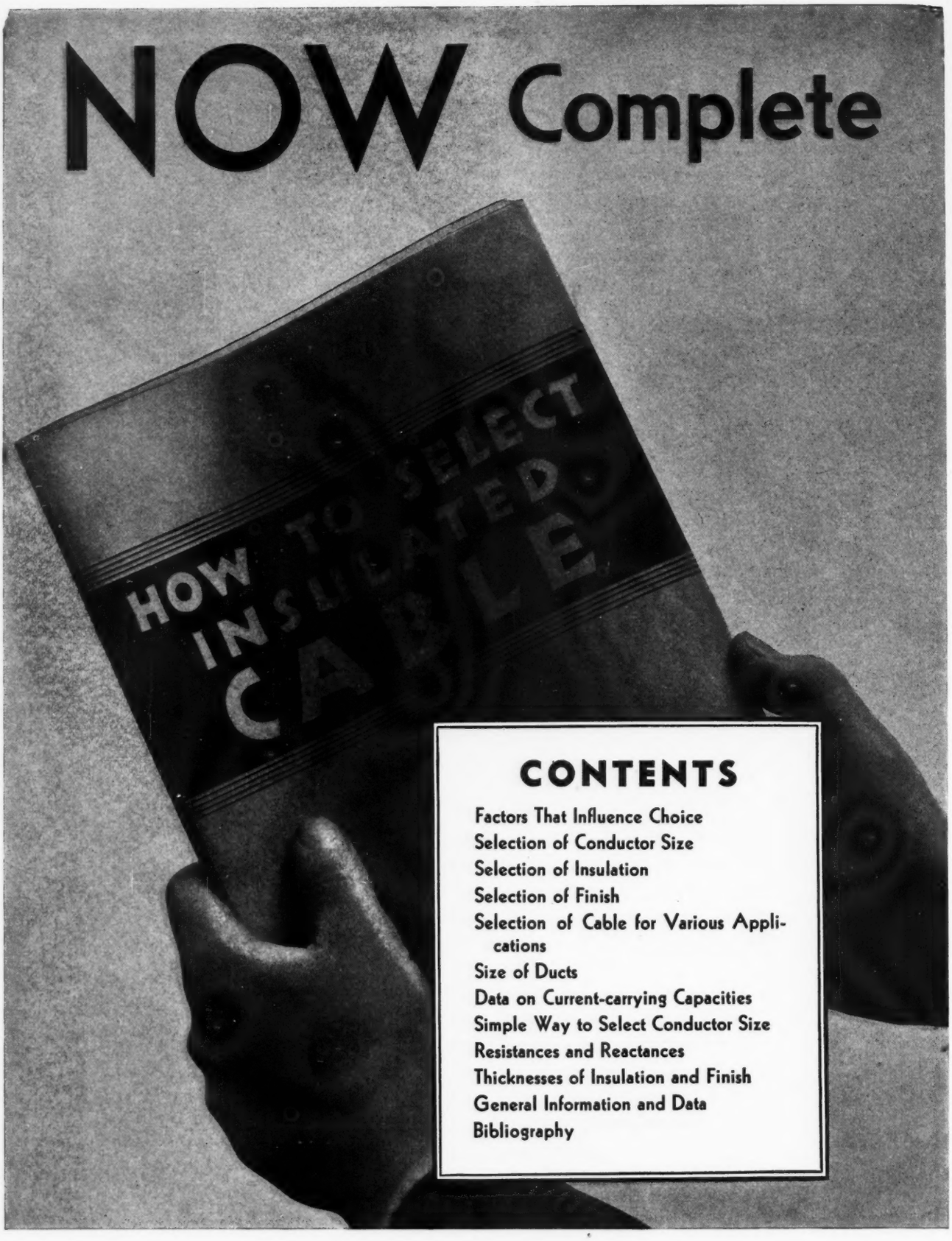

GENERAL ELECTRIC

Information on *How to Select Insulated Cable*

Another service for cable users . . . this NEW 80-page reference book on the selection of insulated cable

IF you are interested in the selection of insulated cable for electric circuits, you will find this new reference book indispensable. It represents a new service to cable users, and puts information on selecting cable into handy, readily accessible form.

A Cable Encyclopedia

Data which have never before been conveniently accessible are now available within a single cover. Material hitherto unpublished is contained in this book. Other subject matter includes the substance of articles on cable that have appeared in technical papers — condensed, rearranged, and well-indexed. Useful data have been put into easy-to-understand chart and table form.

Those Who Can Use This Information

Cable engineers, electrical engineers in industrial plants, consulting engineers, architects, contractors, college professors— all will find *How to Select Insulated Cable* of exceptional value.

Free

How to Select Insulated Cable will be sent without charge to those requesting it. We feel, however, that this book represents a valuable service to cable users, and we should like to be sure that every copy is put to good use. We are in a position, for the time being, to fill all requests for it. If you feel that you have need for a copy, we shall be glad to send you one — free and without obligation. Address the nearest G-E office, or General Electric, Dept. 6B-201, Schenectady, N. Y. The coupon is for your convenience.

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Please send me a copy of *How To Select Insulated Cable*, GEA-1837.

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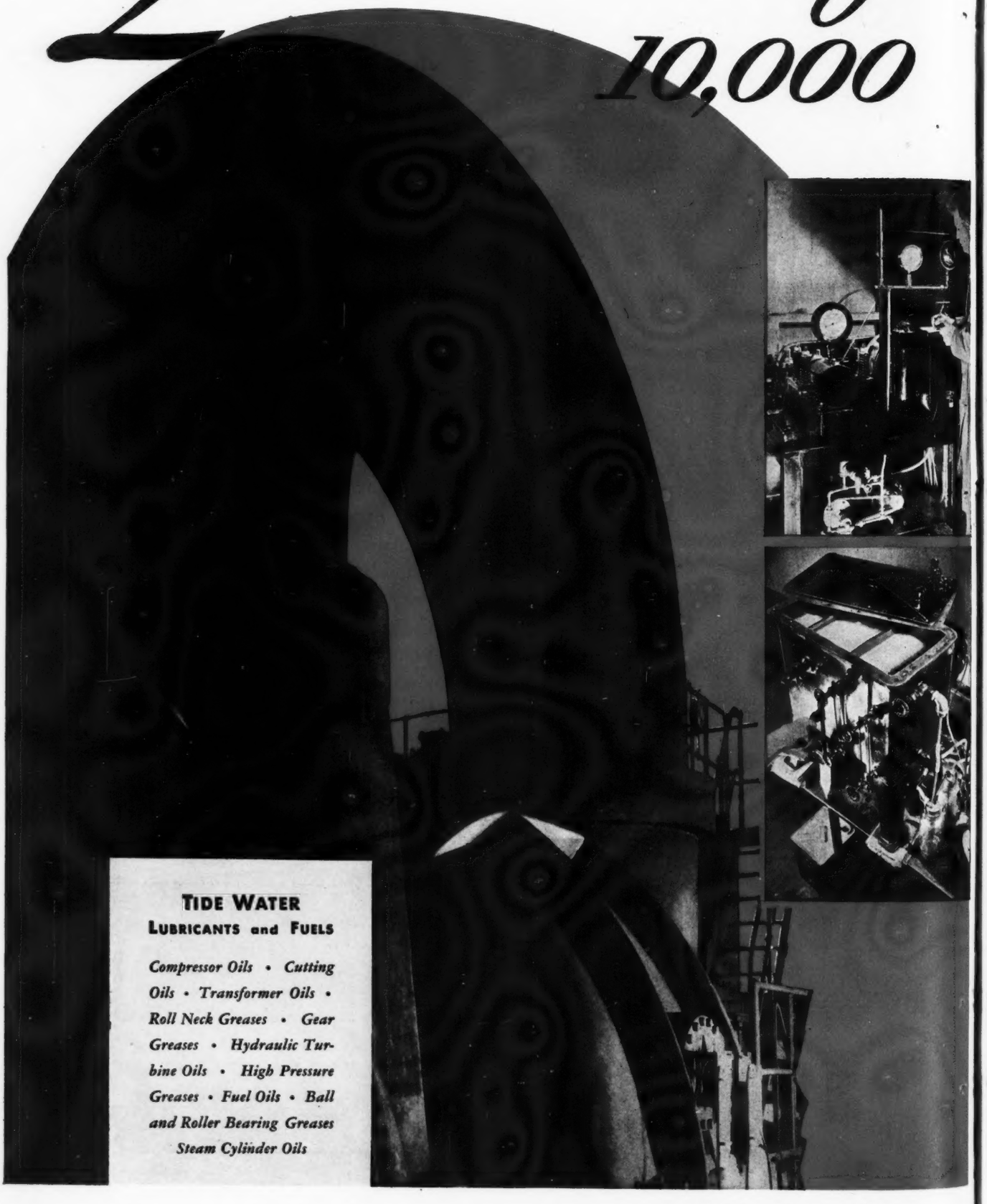


TIDE WATER
LUBRICANTS and FUELS

Compressor Oils • Cutting Oils • Transformer Oils • Roll Neck Greases • Gear Greases • Hydraulic Turbine Oils • High Pressure Greases • Fuel Oils • Ball and Roller Bearing Greases Steam Cylinder Oils

TIDE WATER TURBINE OILS

ARE GUARANTEED TO GIVE

minimum service hours

For many it will be sufficient that Tide Water—a refiner of quality oils and greases—guarantees its Tycol Turbine Oils to give a minimum of 10,000 service hours to any turbine. Others may wish to know something of the superior performance which enables a refiner to take the revolutionary step of guaranteeing a definite number of service hours.

1 THE NAVY WORK TEST

—the Navy regards as satisfactory any turbine oil which shows a work factor of over 60% on the standard 100 hour work factor test.

For the 100 hour period, Tycol Edeleanu-refined Turbine Oil showed a work factor of 98.3%. When the test was continued to 300 hours—three times the standard Navy test period—the work factor was still over 94%.

2 THE STANDARD FUNK TEST

—the standard Funk Sludging Machine subjects turbine oil to the combined action of water, air and metals at a temperature of 200°F.—far higher than actual operating temperatures. Each hour of Funk machine operation before 1% sludging point is reached means hours of turbine service—many estimate it at 100 hours per Funk hour.

It required *850 hours* of continuous circulation in the Funk Sludging Machine to form 1% of sludging emulsion in Tycol Turbine Oil.

The acidity of Tycol Turbine Oil after the 850 hour Funk test was *zero.*

Performances like the above make possible the conservative and unqualified guarantee of 10,000 service hours from Tycol Edeleanu-refined Turbine Oils. In many turbines, Tycol Oils can be guaranteed to give 20,000 . . . 30,000 hours . . . even longer service.

TIDE WATER OIL COMPANY • 17 Battery Place, New York, N.Y.

TIDE INDUSTRIAL TYCOL OILS & GREASES WATER

C O U P O N

TIDE WATER OIL COMPANY
17 Battery Place, New York, N.Y.

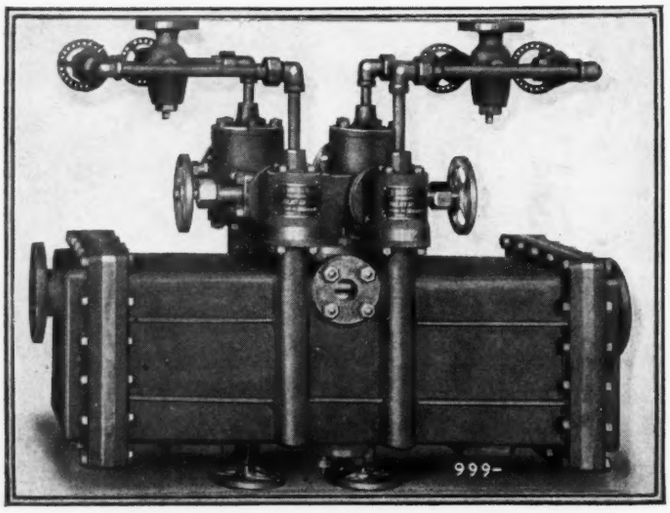
Gentlemen: Please send me complete information concerning Tide Water's Improved Turbine Oil.

Name.....

Company.....

Address.....

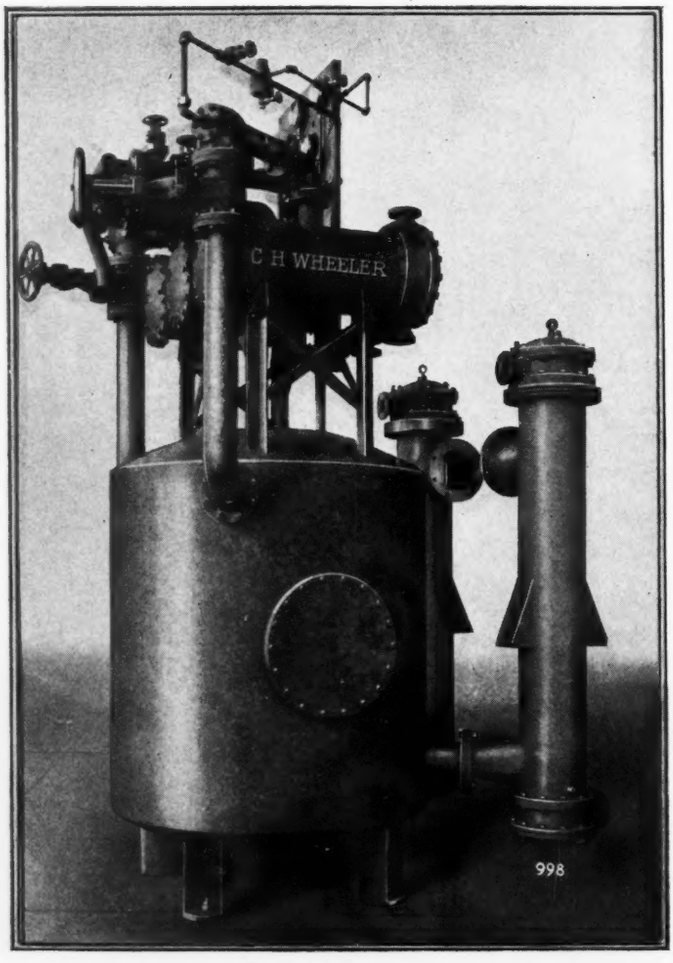
City..... State.....



for 30 years

we've specialized in heat transfer and vacuum producing equipment.

C. H. WHEELER *of* PHILADELPHIA



ABOVE Air Pumps for U. S. Navy embodying light weight and compactness.

BELOW Special Steam Air Ejector Unit for Binary Cycle Mercury Turbine installations.

The C. H. Wheeler organization pioneered in heat exchange and vacuum producing equipment. C. H. Wheeler engineers are specialists in this field.

Steam Jet Vacuum Cooling Equipment utilizing pressure or exhaust steam for its operation.

Tubejet Steam Jet Air Ejectors for vacua up to 1 mm. absolute (29.96 in. mercury.)

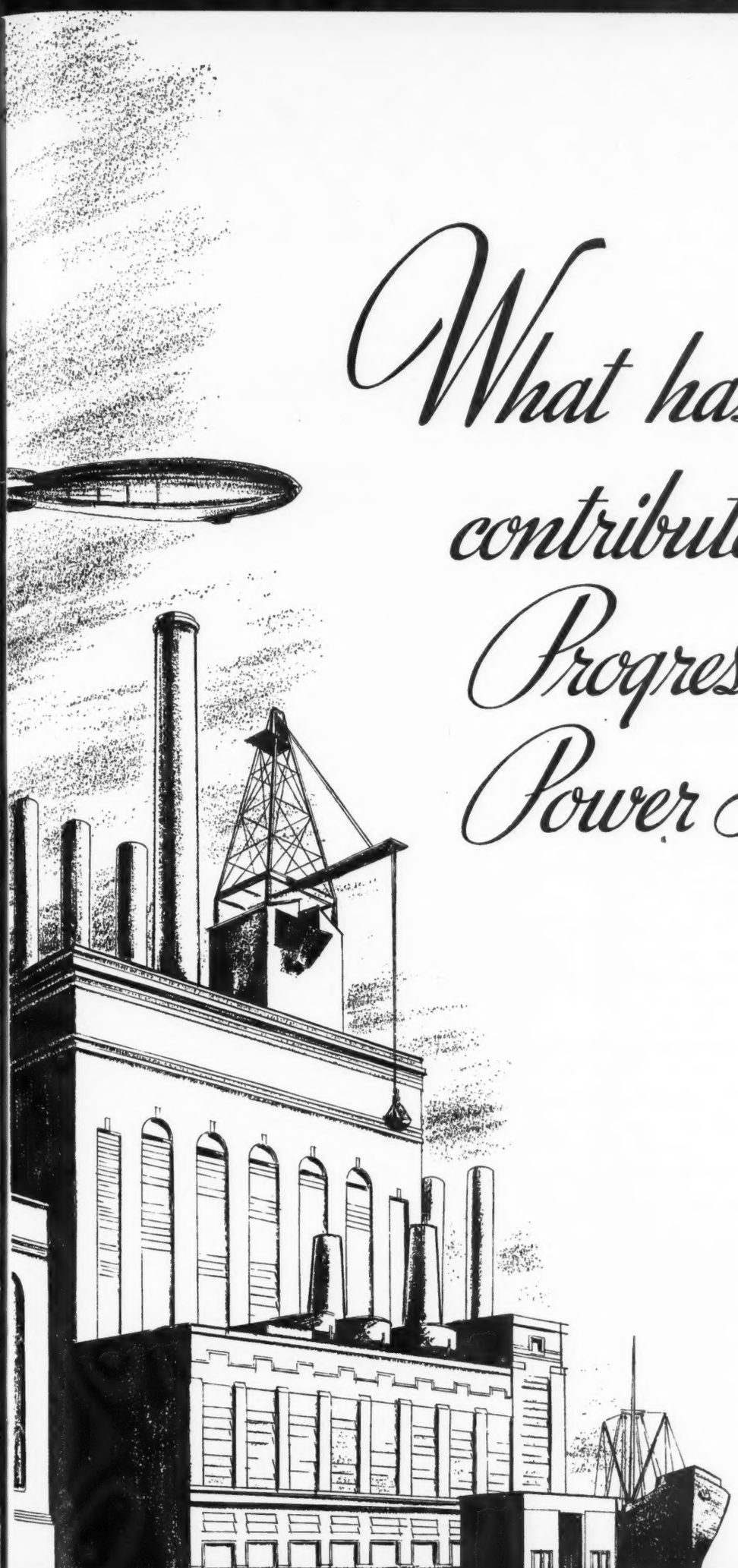
Steam Condensers of highest efficiency.

Heat Exchangers for all purposes.

Water Cooling Towers of all types.

On past performance we solicit your inquiries for equipment to meet today's requirements.

C. H. WHEELER MANUFACTURING CO.
19th St., Lehigh and Sedgley Aves., PHILADELPHIA, PA.



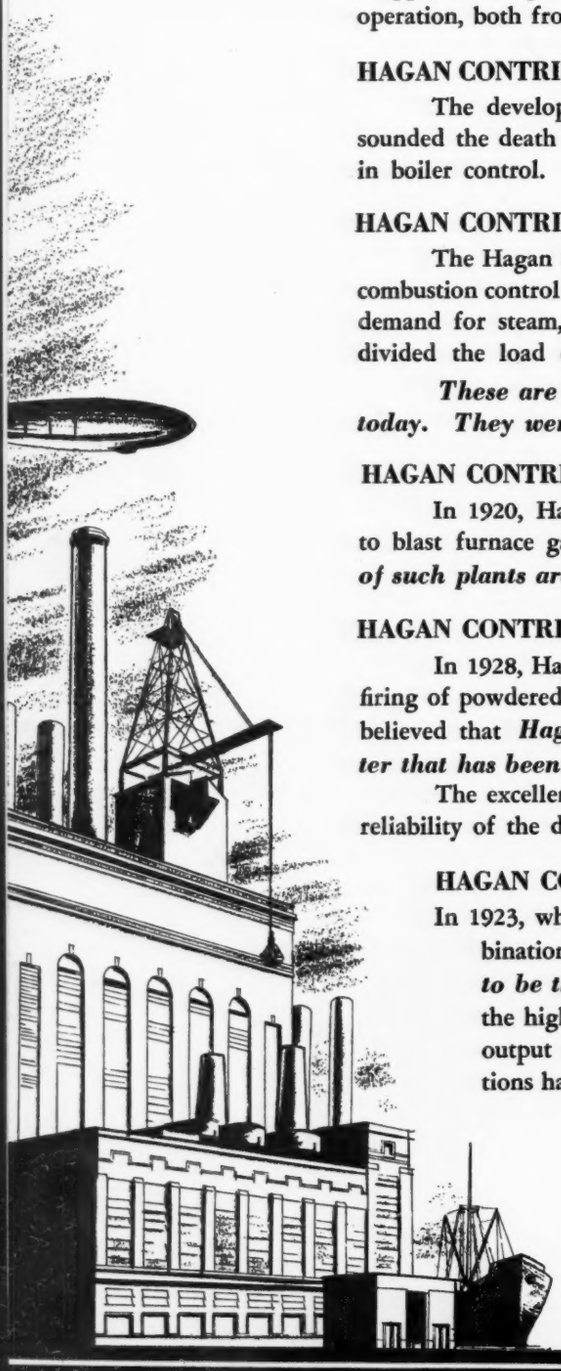
What has Hagan contributed to the Progress of the Power Field?

20 YEARS WITH HAGAN CONTROL 10 YEARS WITH HALL SYSTEM AND BUROMI

Blazing two

Automatic Combustion Control . . .

UP UNTIL TWENTY YEARS AGO the automatic control of a boiler plant consisted of a steam pressure regulator that slapped the stokers, fans, and dampers wide open when the steam pressure dropped a few pounds, and slapped them shut again when the pressure went up. It was a ruinous operation, both from the standpoint of fuel waste and plant maintenance costs.



HAGAN CONTRIBUTION No. 1

The development of the Hagan Master Regulator with its incremental steam flow response sounded the death knell of all open and shut regulators, and marked the beginning of a new era in boiler control.

HAGAN CONTRIBUTION No. 2

The Hagan Corporation was the first organization in America to make available a system of combustion control that automatically proportioned fuel and air to a furnace in accordance with the demand for steam, adjusted the air delivery to the fuel bed in accordance with its resistance, and divided the load equally among all boilers in service.

These are the essential features of every combustion control system on the market today. They were advocated by Hagan and patented over twenty years ago.

HAGAN CONTRIBUTION No. 3

In 1920, Hagan Control for accurately metering air in accordance with gas flow was applied to blast furnace gas fired boilers, and a new standard of efficiency established. ***Ninety percent of such plants are controlled that way today.***

HAGAN CONTRIBUTION No. 4

In 1928, Hagan developed and put into operation the first control system for the combination firing of powdered coal and blast furnace gas. Such systems are tremendously complicated, and it is believed that ***Hagan Corporation has made every completely-automatic plant of this character that has been installed.***

The excellent results secured over a period of years are a splendid tribute to the simplicity and reliability of the different Hagan control units that enter into such a system.

HAGAN CONTRIBUTION No. 5

In 1923, when one of the first high pressure boiler installations was made to work in combination with existing low pressure units, Hagan designed and installed ***what is believed to be the first pressure reducing and de-superheating system*** to deliver steam from the high pressure header at proper pressure and temperature conditions to supplement the output from the low pressure boilers. Since that time a large number of similar installations have been made, many of them having capacities as high as 500,000 lbs. per hour.

HAGAN CONTRIBUTION No. 6

Hagan Corporation was the first to demonstrate the possibility of automatically controlling boiler plants using Roller Mills for direct firing.

HAGAN CORPORATION

trails

Scientific Boiler Water Conditioning

HAGAN CONTRIBUTION No. 7

It was the Hagan Corporation that made the first successful direct-fired powdered coal boiler installation. This work was the forerunner of today's "direct firing."

HAGAN CONTRIBUTION No. 8

Large boiler units with widely-separated auxiliaries, called for a centralized system of automatic and manual control. The Hagan Unit System was developed to combine accuracy of control with the maximum of flexibility and adjustment, and the minimum of complication. These systems are daily proving their value in the finest boiler plants in this country. Over a period of twenty years Hagan has pioneered in the automatic combustion control field and watched the art develop from crudity to unnecessary complexity. Simple—rugged—dependable sufficiency of control that will function continuously to perform automatically what is expected of it, characterizes all Hagan installations.

TWENTY YEARS OF LEADERSHIP in this field cannot be denied the Hagan Corporation.

★ ★ ★

WE HAVE TOUCHED the "high spots" of Trail No. 1. Let us go back twenty years and do the same with Trail No. 2.

If we knew no more today than we did then of boiler-water conditioning, every high pressure boiler would be in the scrap pile.

Sixteen years ago Hagan Corporation recognized the opportunity for service in this field. Before real headway could be made a new foundation had to be built. This was started in the laboratories of the United States Bureau of Mines, where Dr. R. E. Hall and a corps of Hagan chemists and engineers labored for four and a half years. Carnegie Institute of Technology Bulletin 24 and forty other technical publications tell the story.

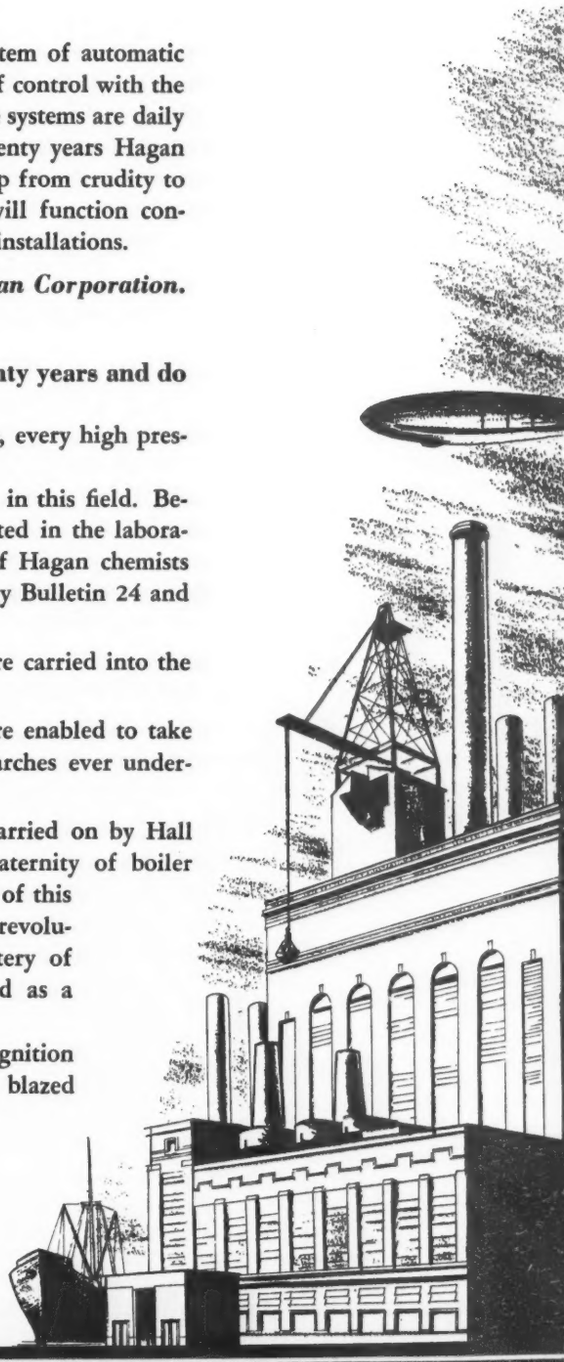
By the formation of Hall Laboratories, Inc., the benefits of this research were carried into the finest central stations of America.

By the formation of The Buromin Company, all plants, large and small, were enabled to take advantage of what has been acknowledged to be one of the most important researches ever undertaken in the interest of steam generation.

Out of the work started by Hagan Corporation sixteen years ago and carried on by Hall Laboratories has grown a new conception of boiler-water chemistry and a new fraternity of boiler water chemists. One valuable contribution after another has sprung from the roots of this undertaking. The development and making available of Hagan Phosphate has revolutionized the treatment of boilers, and the application of this product to the mastery of calcium in all processes where water is used, is recognized by the scientific world as a contribution of far-reaching and incalculable value.

The recent award to Dr. Hall by the American Chemical Society in recognition of "outstanding service to chemistry" indicates that this second trail has not been blazed in vain.

Profiting by experience, and holding fast to our ideals of service, we will continue our journey along the two paths we have chosen.



PITTSBURGH, PENNA.

Potomac Electric Power Co.
Buzzard Point Station
Alton Box Board & Paper Co.
★American Can Company
★American Hide & Leather Co.
★American Locomotive Co.
American Window Glass Company
★The Aspinook Company
Bennings Station Power Plant
★Bellefield Boiler Plant
Brooklyn Borough Gas Company
★Calumet & Hecla Consolidated Copper Co.
★Carnegie Institute of Technology
Champion Machine & Forging Co.
★Chase Brass & Copper Co.
Chatham Manufacturing Co.
★Chicago Carton Company
★Cincinnati Rubber Co.
★Columbian Paper Company
★Crocker Burbank Company
Crystal Springs Bleachery
★Duquesne Light Co.
Edgewater Beach Hotel
★Falls City Ice & Beverage Co.
Franklin Heating Station
★Gilbert Paper Co.
★Goodyear Tire & Rubber Co.
Great Meadow State Prison
Great Northern Railroad Co.
Harvard Medical School
Hastings State Asylum
★Hollingsworth & Whitney Co.
★Hope Natural Gas Co.
★Indianapolis Power & Light Co.
Interstate Power Company
★Jacob E. Decker & Sons Co.
★Kalamazoo Vegetable Parchment Co.
★Kroger Grocery Company
Large Distillery
★Libbey-Owens-Ford Glass Co.
★Lillybrook Coal Co.
★Marathon Paper Mills Co.
Medium Security Prison

TEN MILLION BOILER HORSE-POWER

RESPONDING EFFICIENTLY to

HAGAN CONTROL

IN PLANTS SUCH AS

THESE

FIVE MILLION BOILER HORSE-POWER

MAINTAINED FREE FROM SCALE AND CORROSION

AND SAFE FROM EMBRITTLEMENT by

HALL LABORATORIES

AND

BUROMIN COMPANY

IN PLANTS SUCH AS

THESE

Michigan Limestone & Chemical Co.
Minnesota State School for the Deaf
Minnesota State School for Feeble Minded
★Mississippi Valley Barge Line Co.
Monson State Hospital
New England Distillery
New York Central R. R.
Ohio Salt Co.
★Olympic Forest Products Co.
Oscar Meyer & Company
A. Overholt & Company
Overman Cushion Tire Co.
Pacific Mills
Pennsylvania Industrial School
Pennsylvania R. R. Company
★Pennsylvania Salt Co.
★Pennzoil Co.
Perennial Dye & Print Works
Pilgrim State Hospital
Public Service Electric & Gas Co.
Raritan River Power Co.
★Rhinelander Paper Co.
Schmidt Brewing Co.
City of Springfield, Ill.
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★Tennessee Coal, Iron & R. R. Co.
Texas A. & M. College
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University of Chicago
University of Minnesota
University of Texas
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Virginia Polytechnic Institute
Weirton Steel Co.
Western Reserve University
Westinghouse Electric & Mfg. Co.
★West Penn Power Co.
West. Va. Hydro Electric Co.
★West Virginia Pulp & Paper Co.
★Wheeling Steel Corporation
Youngstown Sheet & Tube Co.

Anheuser-Busch Company
★Bethlehem Steel Co.
Bigelow-Sanford Carpet Co., Inc.
★Brown Company
Campbell Soup Company
★Carnegie Steel Company
★Chrysler Corporation
J. & P. Coats, Inc.
★Curtis Aeroplane Co.
★Eastman Kodak Company
Ford Motor Company
★Georgia Power Company
★Jones & Laughlin Steel Corp.
★Lever Bros. Company
Louisiana Steam Products Co.
Mathieson Alkali Company
★National Tube Company
New York Edison Company
★New York Steam Corporation
Packard Motor Co.
Philip Carey Company
★Pittsburgh Steel Company
Proctor & Gamble Company
Southern California Edison Co.
★Southern Kraft Corporation
Standard Brands, Inc.
Standard Oil Co. of New Jersey
★Tennessee Eastman Co.
United Electric Light & Power Co.
United States Tire Co.
★Virginia Electric & Power Co.
★M. J. Whitall Associates, Ltd.

THE HAGAN CORPORATION is the only organization that can offer you this dual service that hundreds of plants are utilizing so successfully.

Here it is:

Co-ordinate the operation of boilers, stokers, and auxiliaries so that under conditions that are ideal the maximum amount of heat is produced from every pound of coal burned. This is accomplished by a suitable system of Hagan control.

Next, utilize this heat to the greatest advantage by maintaining boiler surfaces free from scale and corrosion. Hall System does this.

A boiler plant operated in this manner functions smoothly, with a maximum of efficiency and safety, and a minimum of maintenance.

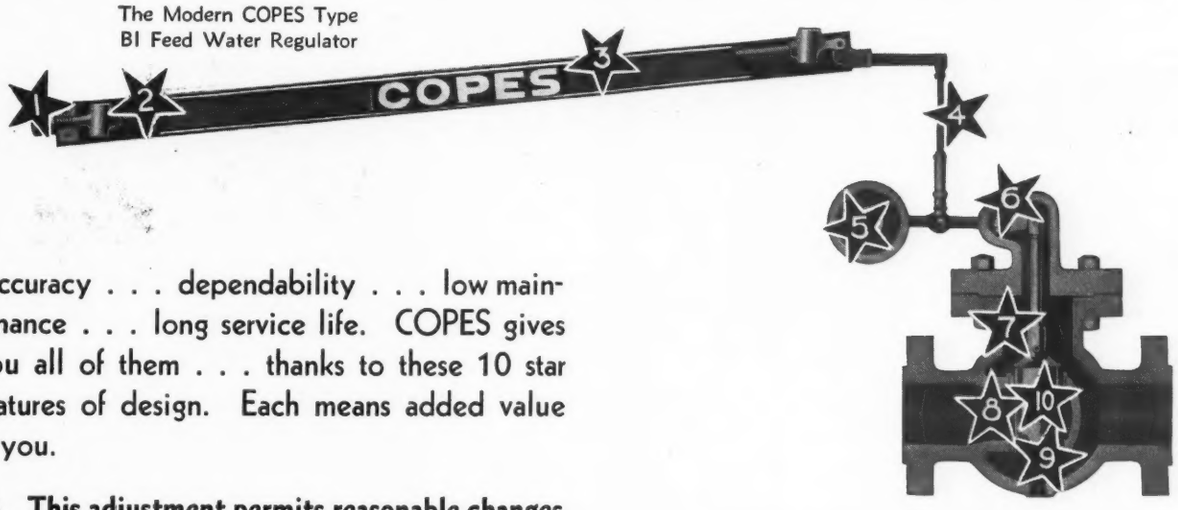
★These plants have taken advantage of "Dual Service," Hagan Control and Hall Systems

HALL LABORATORIES, INC. . . . . BUROMIN CO.

Subsidiaries of **THE HAGAN CORPORATION,** Pittsburgh, Pa.

10 FEATURES

The Modern COPES Type
BI Feed Water Regulator



Accuracy . . . dependability . . . low maintenance . . . long service life. COPES gives you all of them . . . thanks to these 10 star features of design. Each means added value to you.

1 **This adjustment permits reasonable changes in normal water level while the boiler is in service.**

2 **The thermostatic tube must expand when boiler water level lowers . . . must contract when water level rises. It is in tension. No more accurate, powerful or dependable actuating element is known.**

3 **Heavy channel irons . . . you can step on them . . . support the tube and protect it from damage throughout its length.**

4 **Accurately-designed levers multiply the movement of the expansion tube. A rigid strut . . . positive and dependable in action . . . transmits the actuating force to the feed control valve.**

5 **Weight-loaded. Weight opens the valve. The position of the lever shows the amount of control valve opening at all times.**

6 **The horizontal rotating lever shaft reduces friction to less than 2 pounds in the largest sizes . . . compared with 6 to 16 pounds or more with a sliding stem.**

7 **High valve lift . . . from 5/8-inch on 3/4-inch valves to 1-3/8 inches on 6 inch . . . permits more accurate control and increases life of the inner valve parts.**

8 **Sleeve type or tight-seating piston furnished as required by the operating conditions to be handled.**

9 **Rectangular "V" or compound ports are accurately designed for operating conditions specified by the user.**

10 **Valve piston is scientifically balanced under flows and pressures . . . more so than any other make of valve.**

Write for the COPES Catalog. Learn how the modern COPES Regulator can make your boiler operation more efficient . . . economical . . . safe.

NORTHERN EQUIPMENT CO.

611 GROVE DRIVE, ERIE, PA.

Branch Plants in Canada, England, France. Germany, Austria and Italy.
Representatives Everywhere.

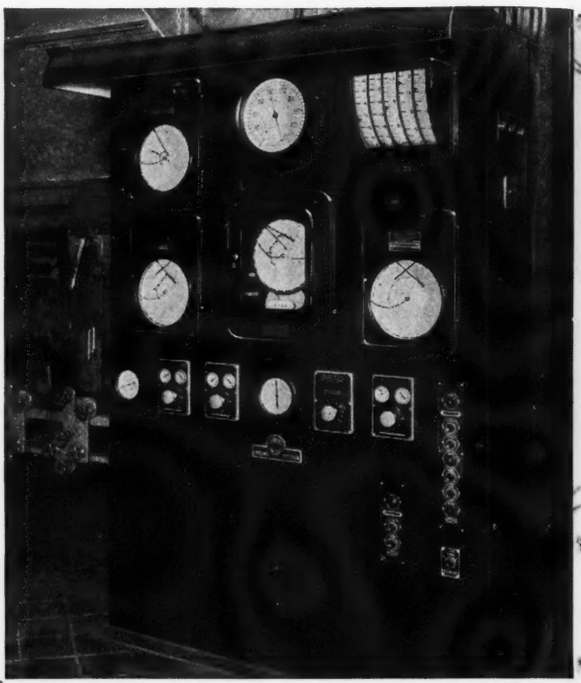
COPES

SYSTEM OF BOILER FEED CONTROL

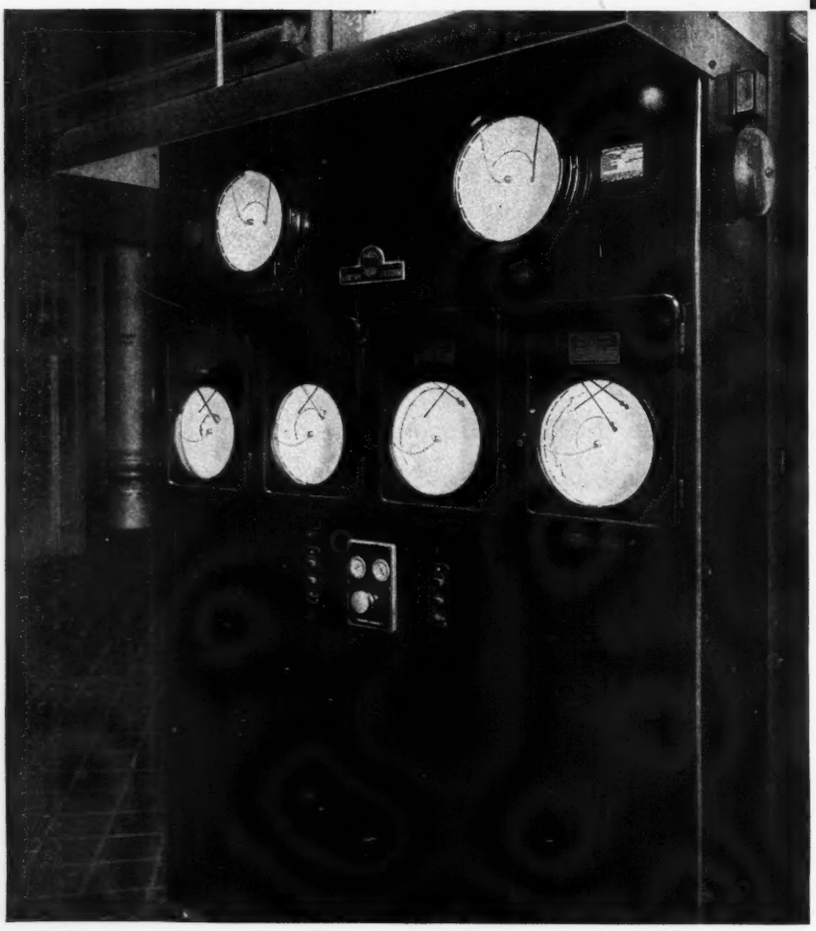
NRA
WE DO OUR PART

COMPLETE INSTALLATION OF ECONOMICAL OPERATION AT WASHINGTON.....

Six 25,000 sq. ft. Boilers in New Central Heating Plant are equipped with Bailey Meter Combustion Control, Bailey Boiler Meters, Multi-Pointer Gages, Feed Water Meters and Regulators, Smoke Density Recorders, Temperature Recorders and Boiler Water Level Recorders.



Individual Boiler Control Panel including Smoke Density Recorder, Feed Water Meter, Bailey Boiler Meter, Boiler Drum Water Level Recorder, Multi-Pointer Gage and Selector Valves for Bailey Meter Control System.

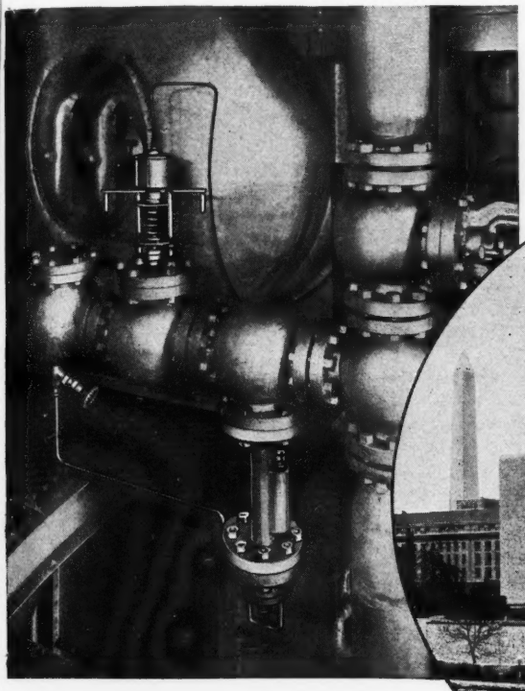


Master Panel of Bailey Meter Control System including Master Steam Pressure Recorder Controller, Steam Flow Meter, Hot Water Return Meter and Temperature Recorder.

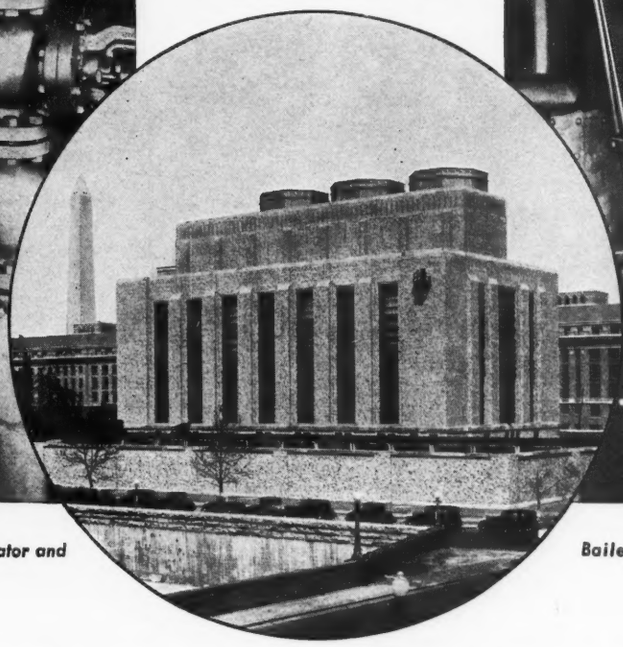
BAILEY METERS

BOILER METERS
COMBUSTION CONTROL
MULTI-POINTER GAGES
FEED WATER CONTROL
SMOKE DENSITY RECORDERS
FLUID METERS
PYROMETERS
RECORDERS

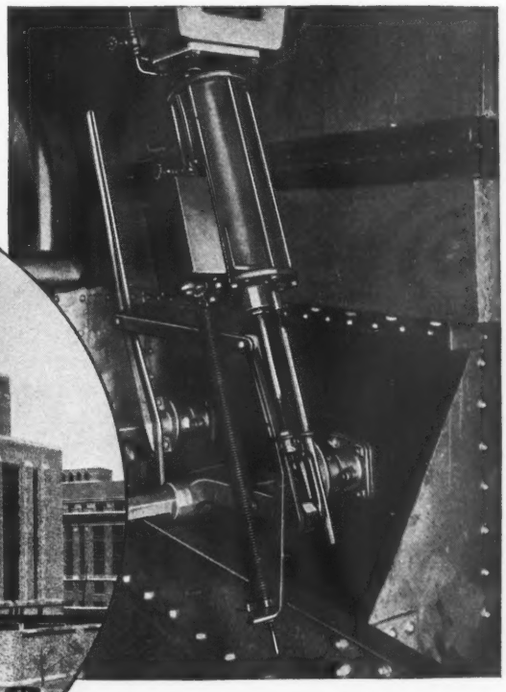
METERS AND CONTROL INSURES SAFE



Bailey Thermo-Hydraulic Feed Water Regulator and Excess Pressure Valve.



Central Heating Plant for Public Buildings, Washington, D.C. United Engineers & Constructors, Inc., Engineers. Rust Engineering Company, General Contractors.



Bailey Meter Control Drive regulating induced draft damper.

ARCHITECTURALLY beautiful, yet thoroughly practical the new Central Heating Plant for Public Buildings at Washington, D. C. is a fitting monument to modern steam plant engineering. Covering an entire city block, it will serve 20 Federal buildings including the White House.

Efficient and safe generation of steam for this purpose is insured by a complete installation of Bailey Meters and Bailey Meter Control. The Bailey Meter Control automatically maintains steam pressure at the desired standard and combustion efficiency at the highest point consistent with economical operation. To accomplish this, fuel feed, induced draft and forced draft are regulated in accordance with variations in steam pressure. The induced draft is automatically readjusted to maintain the desired furnace draft and the fuel feed is automatically readjusted to maintain maximum combustion efficiency as indicated by the Steam Flow—Air Flow relation of the Bailey Boiler Meter. Increased uniformity of operation with attendant fuel savings, safety and low maintenance result from this method of control.

In addition to the automatic combustion control; Bailey Boiler Meters, Boiler Drum Water Level Recorders, Feed Water Meters, Smoke Density Recorders and Temperature Recorders furnish continuous logs of boiler operation. Bailey Fluid Meters and Temperature Recorders for Steam Flow and Hot Water Return furnish records of the station output.

As exemplified in this new station, the modern method of boiler control is by the Steam Flow—Air Flow relation of the Bailey Boiler Meter regardless of whether the meter is used to guide manual or automatic combustion control. If your boilers are 100 h. p. or larger, it will pay you to investigate the savings which can be effected by modernizing your boiler room with Bailey Meters.

• • •

Write for bulletin No. 44-A, which cites over 20 examples of savings effected by the use of Bailey Boiler Meters.

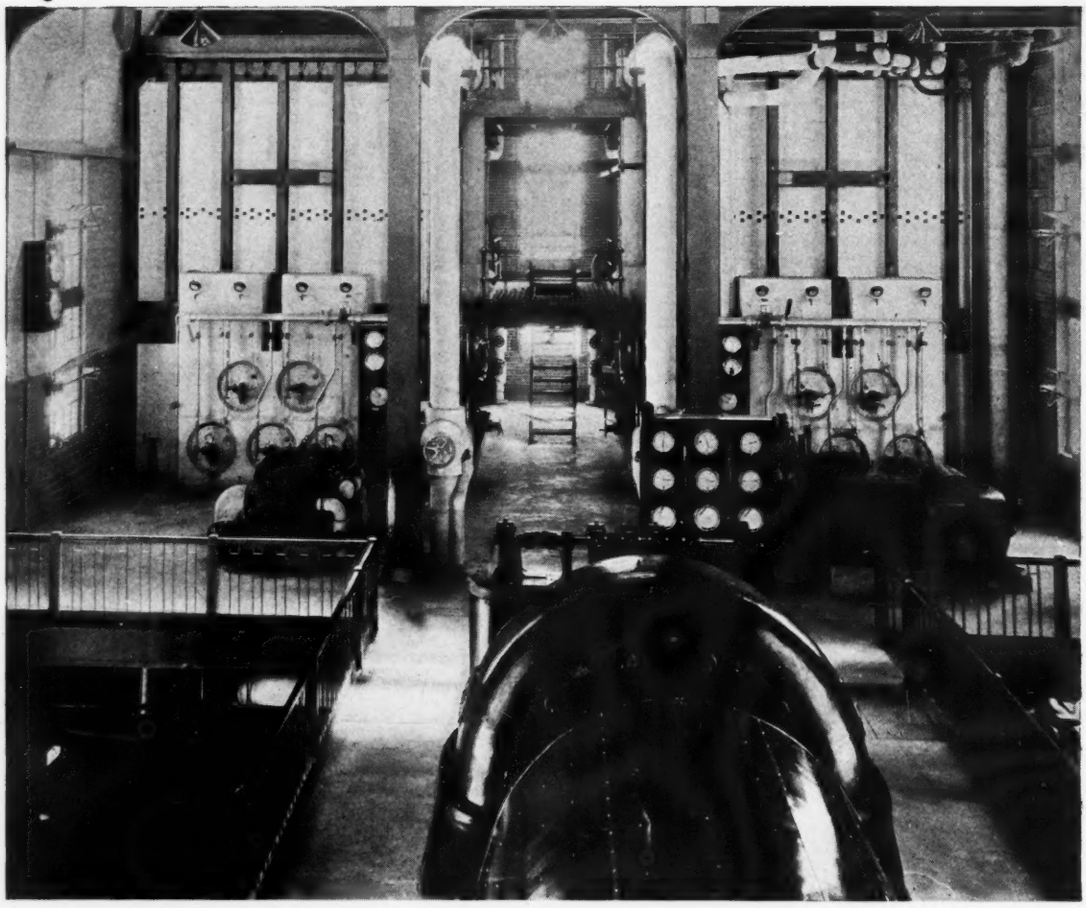
D-28

BAILEY METER CO.

1036 IVANHOE ROAD CLEVELAND, OHIO.

Bailey Meter Company Limited, Montreal, Canada

FOSTER WHEELER



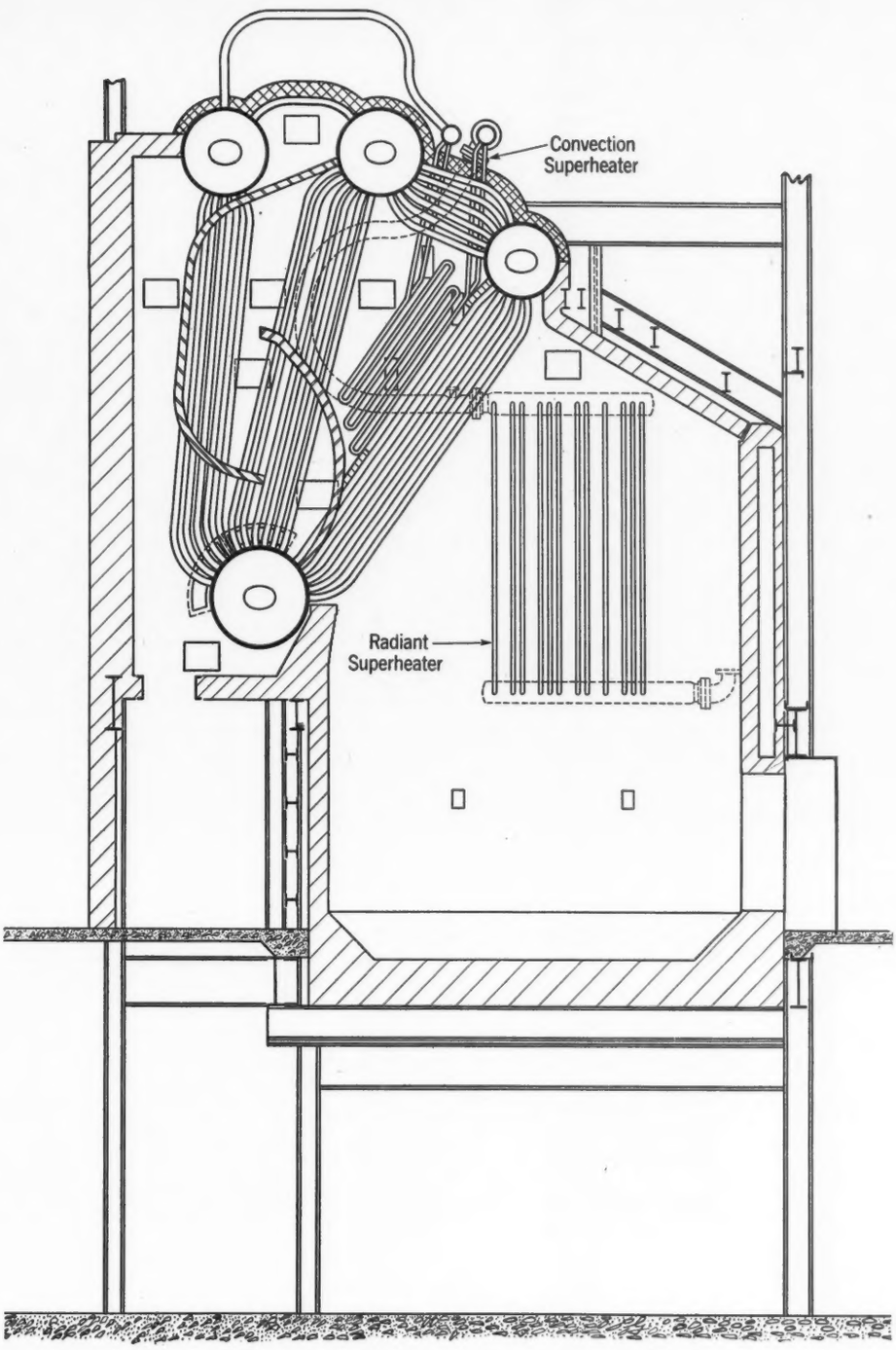
Interior of Dodge City steam plant of the Kansas Power Company, showing prime mover in the foreground and Foster Wheeler boilers in the background. Foster Wheeler evaporators and feed water heaters are located on the floor below.

Boilers and Steam Plant Auxiliaries

The Dodge City plant of the Kansas Power Company is one of the most modern of its size in the country. High efficiency and resultant low power cost are to a large extent due to the performance of its Foster Wheeler equipment. The two steam generators in the boiler room were furnished complete by Foster Wheeler and include 600 hp. boilers with combination convection and radiant superheaters. The operating pressure is 425 lb. per sq.in. and each unit is designed for a capacity of 72,000 lb. of steam per hour. The fuel used is oil and gas fired through five combination burners per furnace.

Makeup water for the power plant is provided by a Foster Wheeler high pressure evaporator which produces 3,600 lb. of pure makeup per hour. In the feed water heating system Foster Wheeler heaters raise the condensate temperature to 321 deg. F. Low pressure and high pressure heaters are both of the closed type, the latter being designed for a working pressure of 500 lb. per sq.in.

Foster Wheeler is fully prepared to cope with any power plant problem involving heat transfer. Its experience includes all phases of central station and industrial plant steam engineering.



Cross section through 600 hp. Foster Wheeler steam generating unit at Dodge City. The unit consists of boiler, combination superheater and oil and gas fired furnace.

Steam plant equipment designed and built by Foster Wheeler includes the following apparatus:

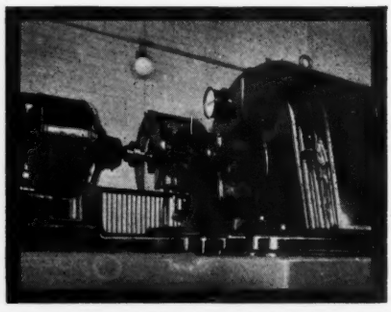
Air Preheaters	Economizers	Pumps
Boilers	Evaporators	Pulverized Fuel Systems
Brass and Copper Pipe and Tubing	Expansion Joints	Ruths Steam Storage Systems
Burners, Pulverized Fuel	Fans, Axial Flow	Steam Generators
Condensers	Feed Water Heaters	Steam Jet Air Pumps
Condenser Tubes	Furnace Hopper Seals	Superheaters
Cooling Towers	Heat Exchangers	Thermo Compressors
Desuperheaters	Heat Recovery Systems, Vacuum	Vacuum Refrigeration Units
Diesel Engine Muffler Boilers	Hot Water Heating Systems	Water Cooled Furnaces

FOSTER WHEELER

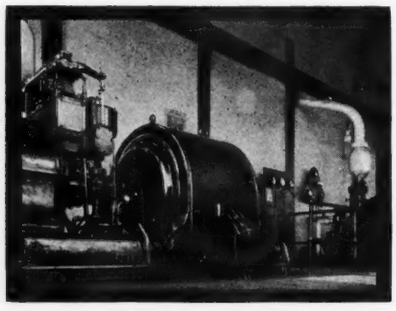
Foster Wheeler Corporation : 165 Broadway, New York

TEXACO
helps maintain peak efficiency for the MONTANA-DAKOTA POWER CO.

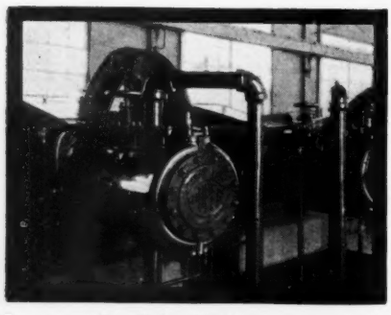
FOR 7 YEARS the efficient plants of the Montana-Dakota Power Company, serving 93 communities, supplying a distribution system of nearly 1000 miles in length, have depended on Texaco for lubrication. Texaco *tested* Lubricants continue in helping maintain peak efficiency for the company's stations, the turbines and other generating and power equipment.



Steam turbine at the Williston plant, North Dakota



The power station at Glendive, Montana

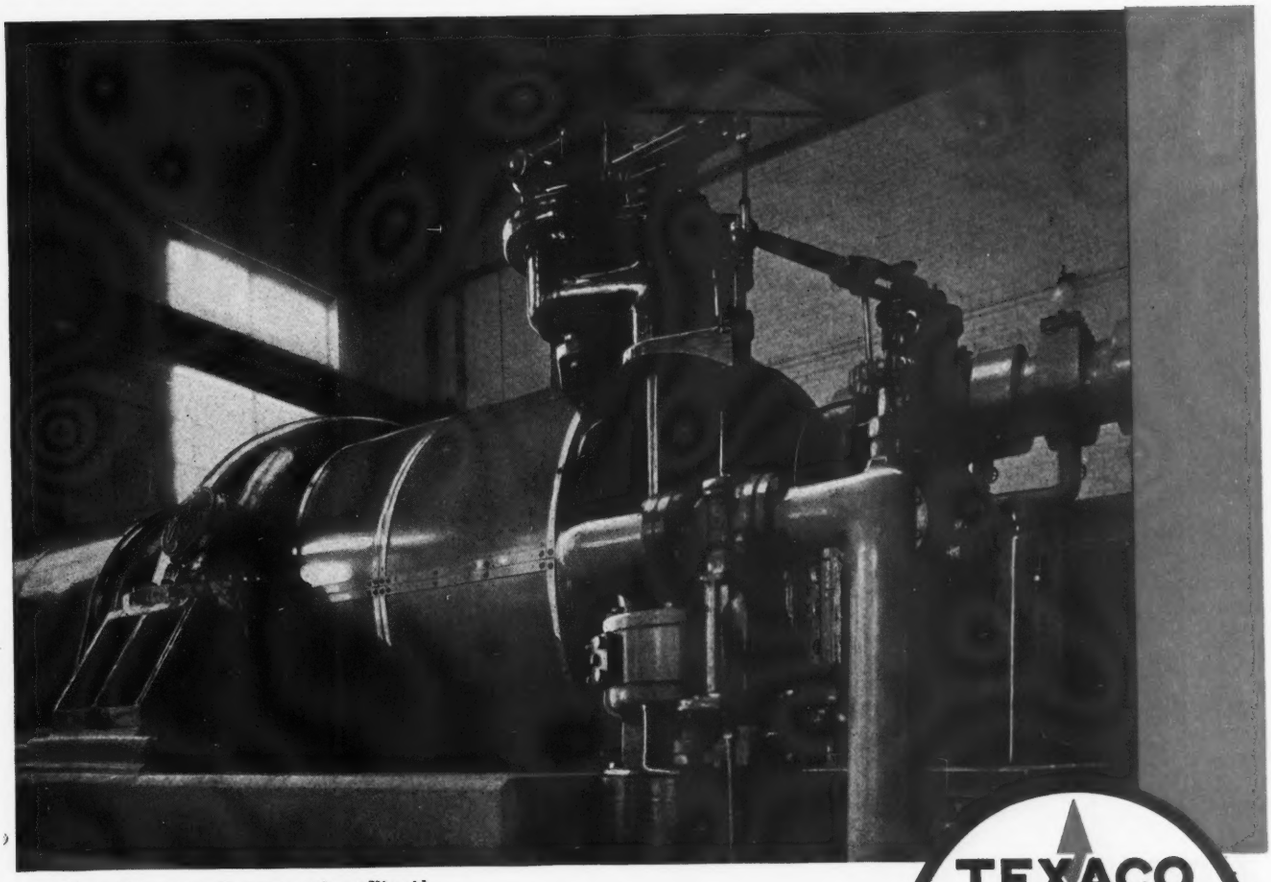


Compressor plant, Baker, Montana

The operating management is highly pleased with the results of the 7 years' record. Texaco here, as in hundreds of other power installations, is giving the greatest satisfaction both in lubricating performance and in the high type of cooperative service rendered by Texaco engineers.

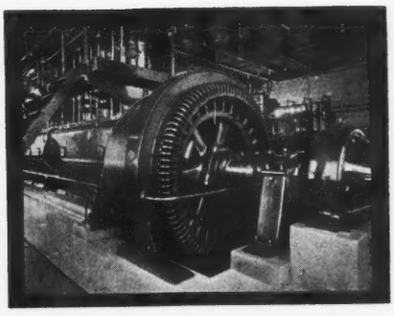
You can gain this same security against lubrication failure, the same lubricating economy and freedom from operating troubles by taking

★ THE TEXAS COMPANY, 135 EAST 42ND ST., NEW YORK CITY



One of the turbine units in the power station at Kincaid

Compressor room at Cabin Creek, Montana



Gas engine at the Baker electric plant in Montana

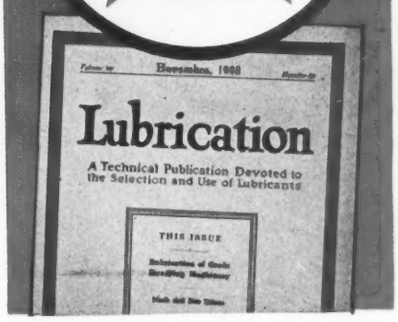
advantage of Texaco *tested* Lubricants and the engineering service offered by The Texas Company.

Texaco Regal Oils for steam turbines have exceptional lubricating qualities, and assured uniformity, resistance to sludging and emulsification. Texaco *tested* Lubricants for every kind of power plant equipment are known for their uniform quality the world over. Use Texaco Lubricants.

Texaco brings you the finest in specialized products and service.

TEXACO

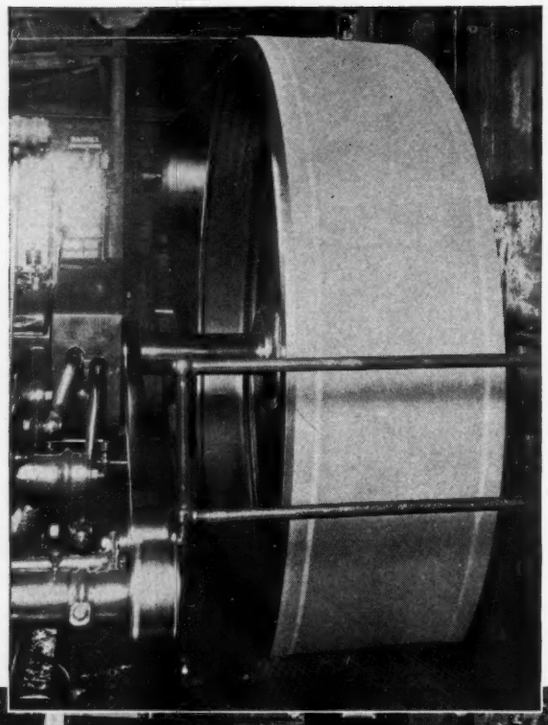
REG. T. M.

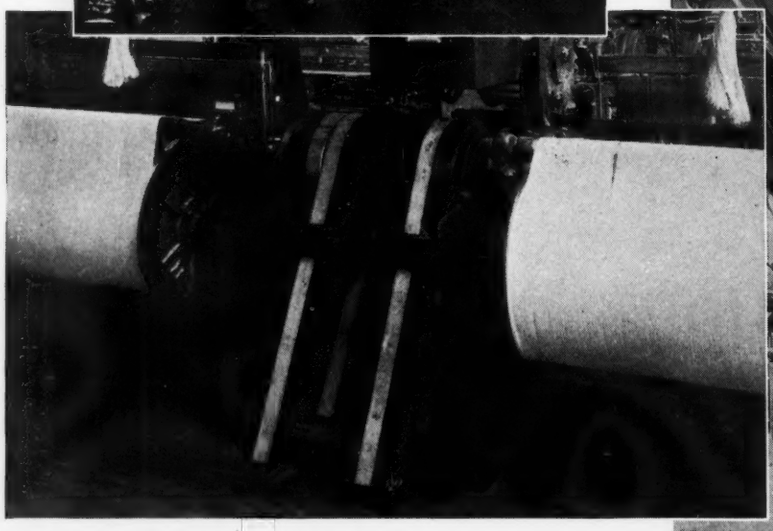


New—Valuable—Complete information on lubrication and operating problems of vital importance to executives and plant personnel. Ask to be put on our mailing list. No cost or obligation. Dept. Z6, The Texas Company, 135 E. 42nd St., New York City.

There is a Texaco Lubricant for every purpose ★

TO KEEP UP PRODUCTION Investigate





Top — *Goodrich Highflex Belting is efficient for the largest main drives, transmitting many hundreds of horse power.*

Bottom — *Highflex is ideal for under-floor drives. These belts will operate for months without the slightest attention.*

● *These special Goodrich Belts (called Highflex Jr.) for cotton mill service are noted for maintaining uniform tension under the most severe conditions. They reduce slippage so decidedly that plant production is always increased when these belts are used.*

Goodrich

ON NEW-DEAL HOURS... better belting...

MANAGEMENT is told to reduce hours, yet plant engineers must maintain production to pay the higher bill. *Let better belting help.*

Goodrich Highflex, of rubber and fabric, is a better belt than you have ever known—it is made to order for difficult times like these:

1. Highflex reduces lost time. It stretches less than leather, and so you will have fewer shut-downs for belt take-up.

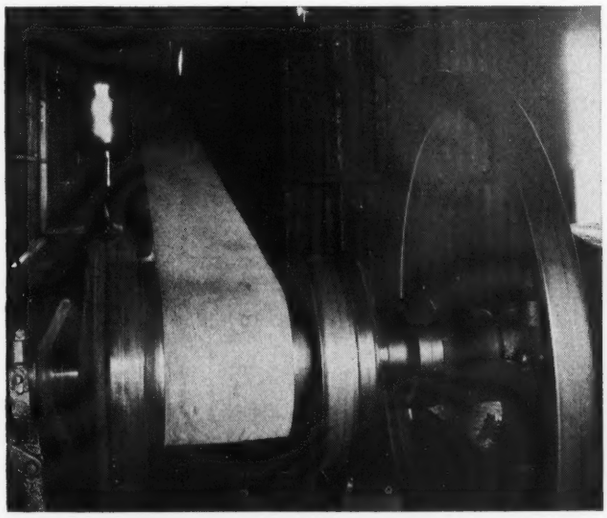
2. Highflex reduces slippage. By maintaining tension, it delivers the full power desired, and so increases machine output. In machine tool operation, this better grip of Highflex has another advantage—it permits a deeper cut.

3. Highflex reduces investment and maintenance. It costs about half as much as comparable leather and lasts fully as long on most jobs. When repair is finally needed, or when splicing is desired, a modern vulcanizer is available for $45, to do the job quickly, right at the machine.

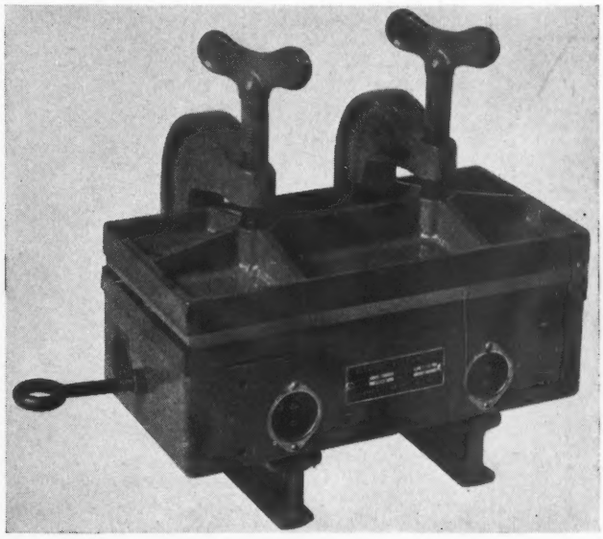
4. Highflex reduces spoilage loss. Because this belt grips the pulley evenly and so delivers constant, steady power, greater precision is possible in many operations, and less spoilage results.

Highflex is the result of 14 distinct improvements which Goodrich has created and built into every length of this modern belt. You can't see these improvements in the belt itself, but you'll see them in your profits the day Highflex starts to work for you.

If you haven't tried Highflex, you haven't tried the one belt which will do the most to keep plant efficiency up, and cost down. Investigate this better belt today . . . call your Goodrich distributor. . . . The B. F. Goodrich Rubber Company, Mechanical Rubber Goods Division, Akron, Ohio.



● *This belt, in service at a large oil well, has been in use 24 hours a day for two and one-half years, and yet is in almost perfect condition today.*



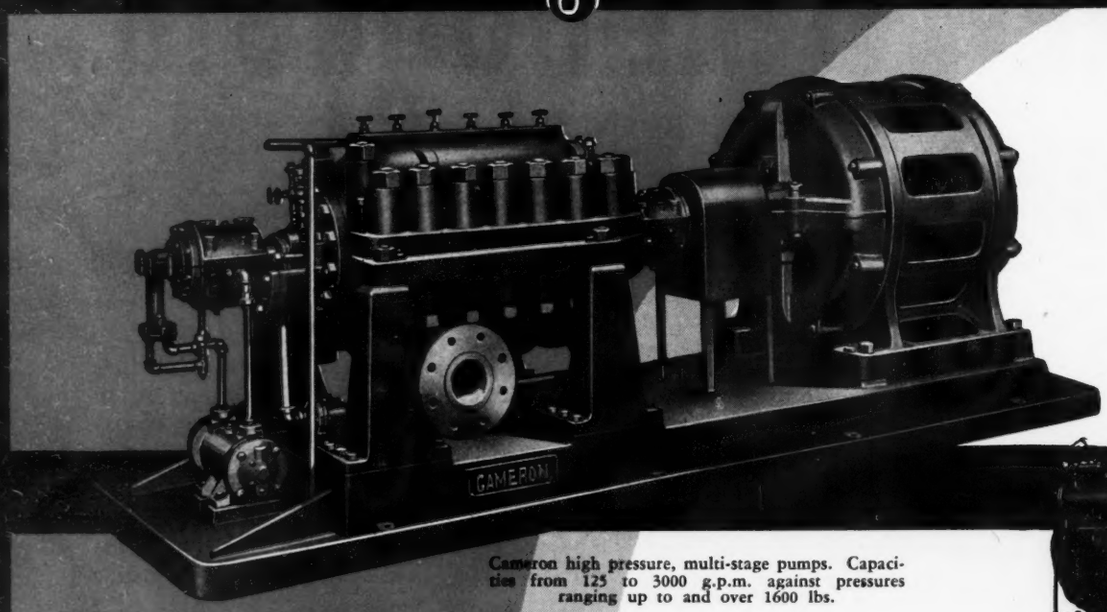
● *Portable Vulcanizer used in making Highflex endless, quickly and inexpensively, at the plant of the user. The size shown, for A. C., sells for $45 and will vulcanize any rubber belt up to 5" in width. Models are available for both A. C. and D. C. installations, and in larger sizes for larger belts.*

ALL *products problems* IN RUBBER

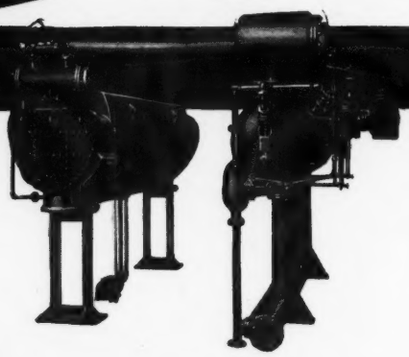
Highflex Belting

We're so proud of Highflex that we give it a permanent brand—the *red edge*—the mark of the belt with the 14 new improvements.

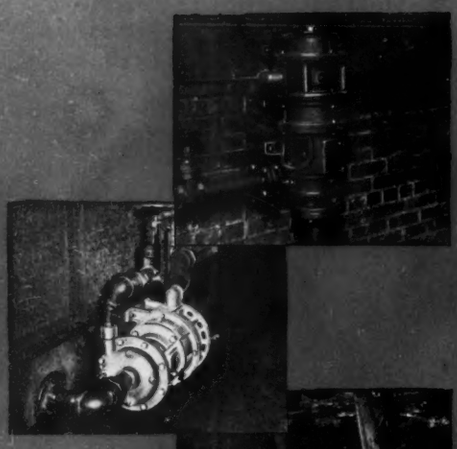
Sound designs that meet the

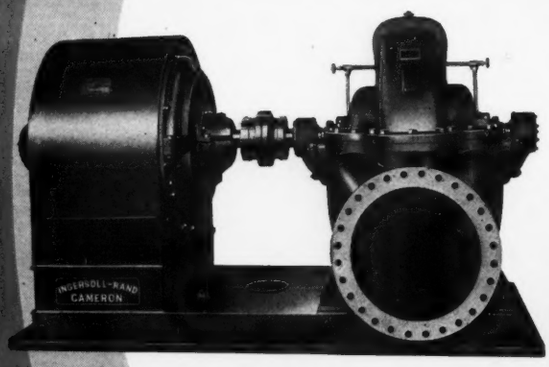


Cameron high pressure, multi-stage pumps. Capacities from 125 to 3000 g.p.m. against pressures ranging up to and over 1600 lbs.

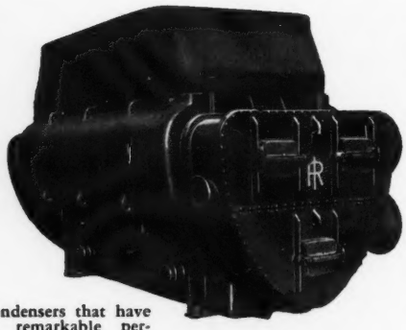


Water vapor refrigerating units. Two types—steam jet and centrifugal.



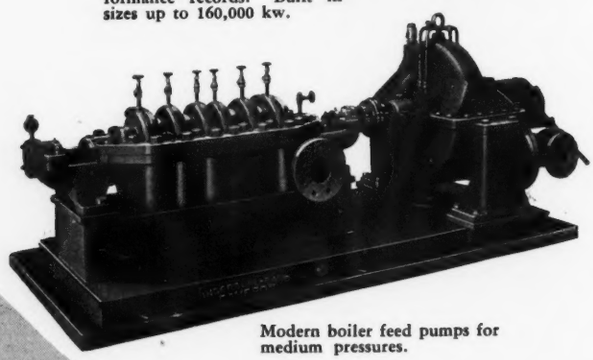


Cameron general service pumps



Surface Condensers that have established remarkable performance records. Built in sizes up to 160,000 kw.

MOTORPUMP — can be mounted in any position. Pump and electric motor in one unit. Capacities 5 to 800 g.p.m. Motors for all current conditions.



Modern boiler feed pumps for medium pressures.

Other IR Products

- Aftercoolers
- Air and Gas Receivers
- Ammonia Compressors
- Portable Compressors
- Turbo-Blowers
- Turbo-Compressors
- Vacuum Pumps
- Barometric Condensers
- Ejector-Jet Condensers
- Rock Drills
- Drill Steel and Sharpeners
- "Jackbits" and Grinders
- Oil-Electric Locomotives
- Hoists—Air and Electric Single- and Double-Drum
- Pneumatic Tools
- Tie Tampers
- "Calyx" Core Drills
- Hot Oil Pumps

needs of TODAY and TOMORROW

Ingersoll-Rand equipment has long enjoyed a reputation for its high standard of performance. The I-R trade-mark has in many ways become synonymous with power plant progress.

Expressed in terms of the service they will render and the money they will save the I-R machines illustrated or listed here represent the greatest values ever offered. Their advanced yet proven designs assure the purchaser of machines that are not only good for today but for years to come.

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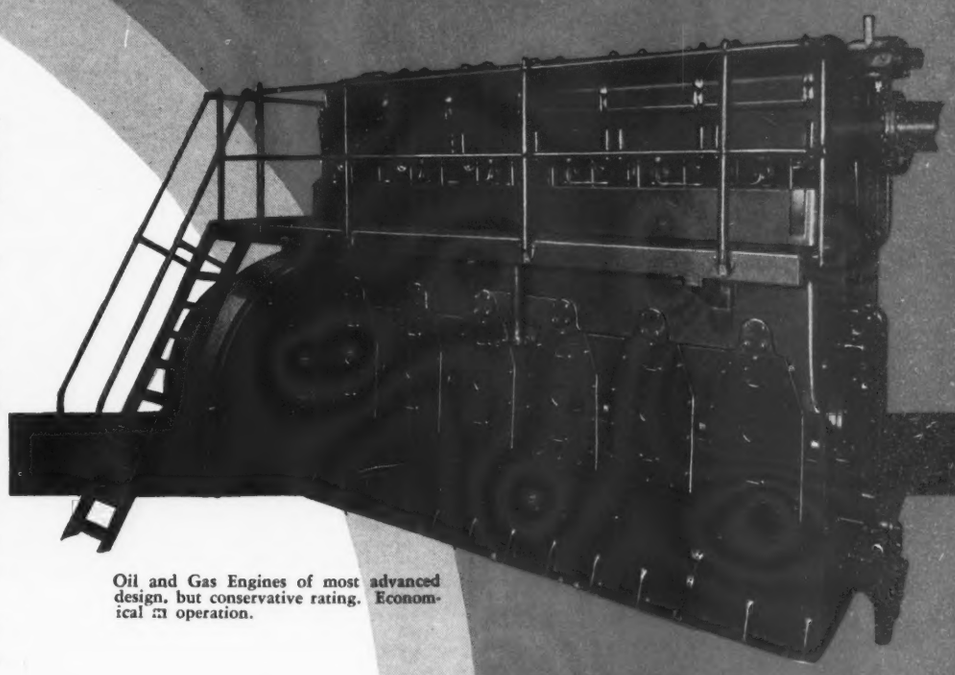
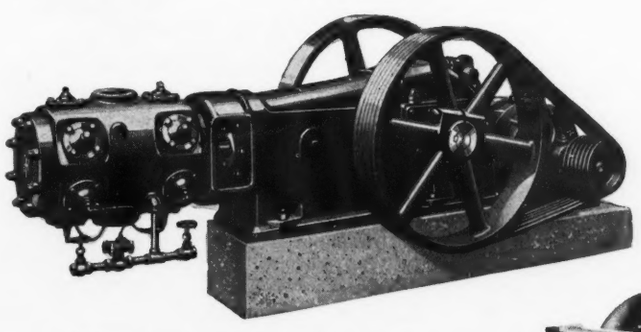
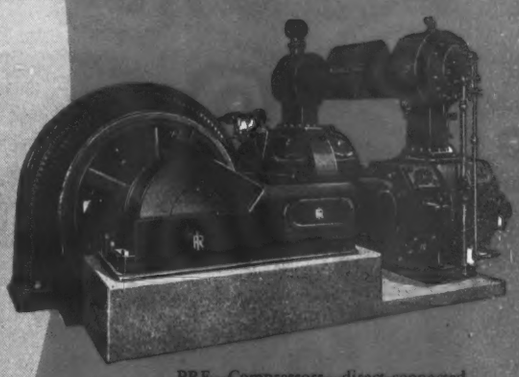


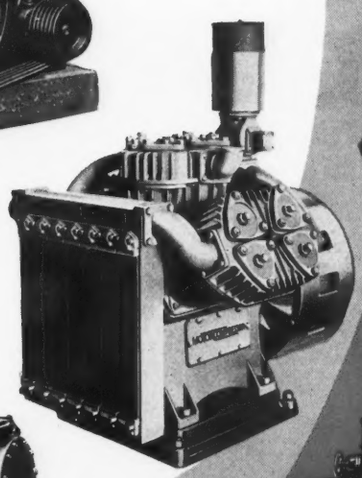
Oil and Gas Engines of most advanced design, but conservative rating. Economical in operation.



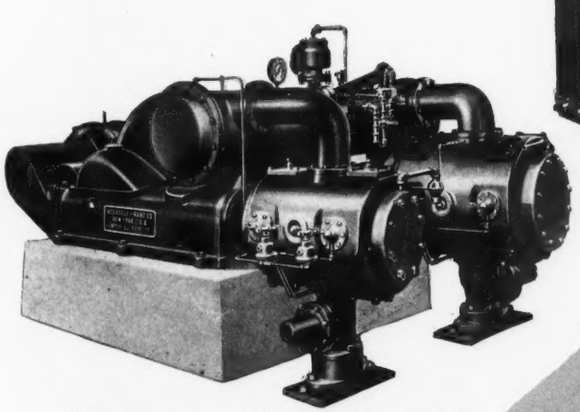
ES Heavy-duty air compressors—15 to 125 hp.



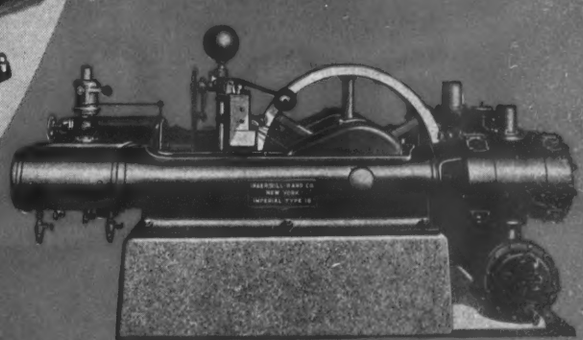
PRE—Compressors—direct-connected, motor driven with I-R patented 5-step clearance control. Capacities up to 12,000 cu.ft. per min.



The Motorcompressor—two-stage, air-cooled with built-in electric motor. Sizes 20 to 50 hp.



XRB—Compressors—efficient, belt-driven machines of compact design.



XPV—Compressors—for highly efficient operation with ordinary saturated or superheated steam at high pressures.

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1887

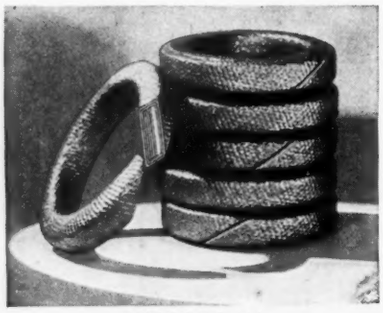
Keeping Pace with Progress for Nearly Half a Century

IT was just a few years before the "gay nineties" that The Garlock Packing Company started its first half century of progress in a small factory at Palmyra, New York.

By integrity of purpose, honesty of product and constant endeavor to render better packing service to its increasing list of customers, Garlock has continued to maintain a commanding position in the mechanical packing industry throughout all these years.

Many new developments in industrial science and engineering have necessitated new equipment and processes. Garlock has kept pace with this great progress by designing and manufactur-

GARLOCK



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High Pressure Ring Packing

GARLOCK 235
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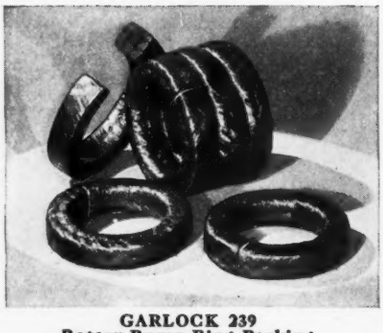
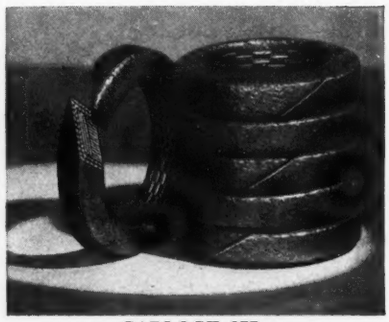
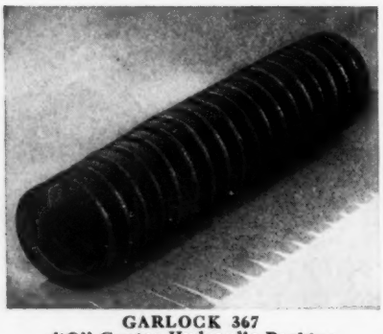


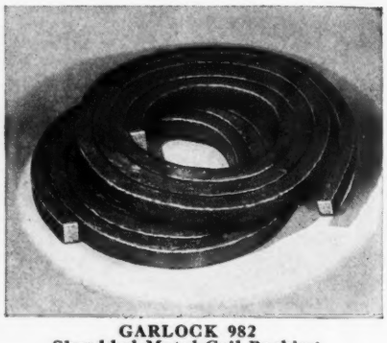
GARLOCK 239
Rotary Pump Ring Packing



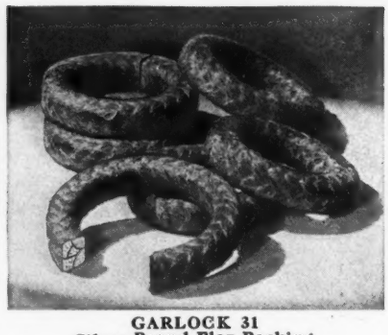
GARLOCK 377
Metalmarine Ring Packing



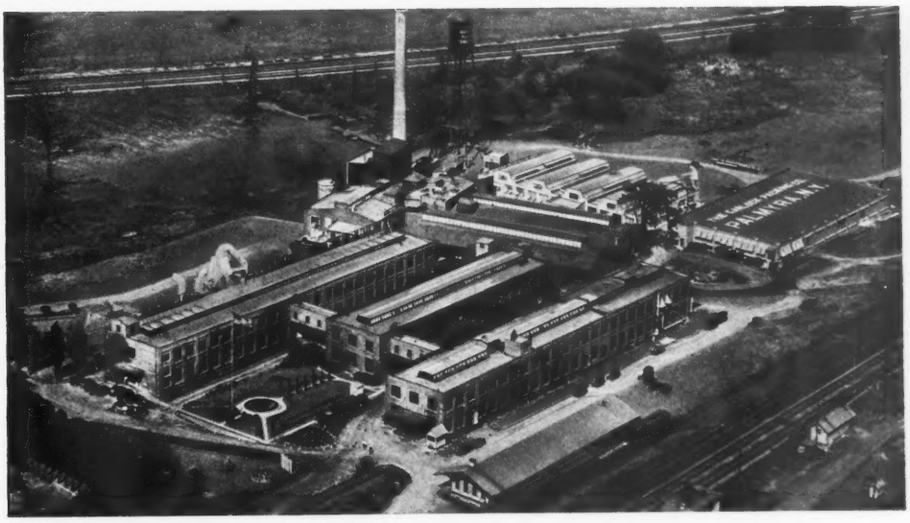
GARLOCK 367
"O" Center Hydraulic Packing



GARLOCK 982
Shredded Metal Coil Packing



GARLOCK 31
Silver Brand Flax Packing



ing new products to meet the specific and exacting requirements of modern industry.

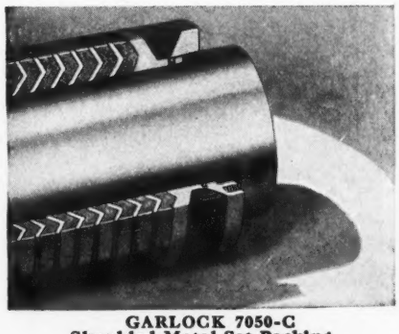
1934 This photo shows the modern Garlock factories at Palmyra, New York. Sales offices and warehouses are located in all principal industrial centers.

Among the hundreds of products in the Garlock line of quality controlled packings there is one suitable for every service application. A few are illustrated on these pages. For other Garlock products consult our general catalog or, better still, ask the Garlock representative to recommend a material for your specific requirements.

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK
In Canada: The Garlock Packing Company of Canada, Limited, Montreal, Quebec.

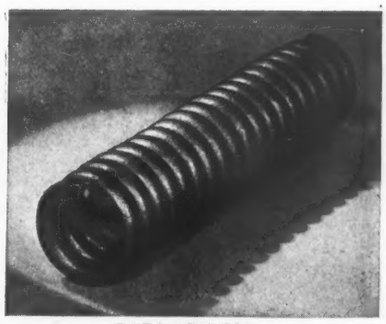
PACKINGS

GARLOCK 333
Low Pressure Ring Packing

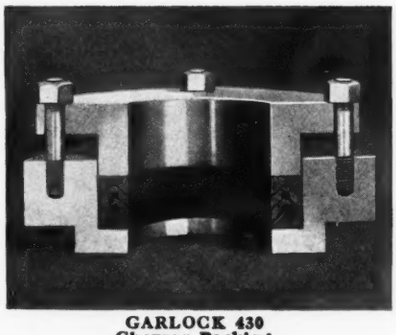


GARLOCK 7050-C
Shredded Metal Set Packing

GARLOCK 261
Special Hydraulic Ring Packing



GARLOCK 254
Ideal Spiral Packing



GARLOCK 430
Chevron Packing

GARLOCK 7022
Compressed Asbestos Fibre Gaskets

GARLOCK 890
Metal Oil Scraper Ring

IN THE POWER

POWER
February, 1900.
34
The Lunkenheimer
Patented "Clip" Gate Valve
SINGLE DISC. DOUBLE SEATED.
The Engineers' Favorite.
Best in Quality.
These Valves are made of Cast Iron and all wearing parts of Gun Metal.
They are superior to thecommon, cheap, brass valves with which the market is flooded.
WHY? BECAUSE they possess all the advantages of a cast-iron pipe fitting (Elbow, Tee, Coupling, Union, etc.), namely:—are heavy and rigid—not injured by expansion and contraction or rough handling in pipe fitting. Joint between body and hub made permanent by an imbedded seamless oval copper wire washer. If you desire the BEST, STRONGEST and MOST DURABLE valve for general purposes on all ordinary pressures, use this valve. IT IS A STANDARD FITTING, OF NEAT APPEARANCE and FULLY WARRANTED TO SATISFY. Made also in All Iron for Cyanide and other acids. Try them and be convinced. Specify them and order through your dealer.
Catalog of superior brass and iron engineering appliances.
The Lunkenheimer Company, Cincinnati, Ohio, U. S. A.
Sole Manufacturers.
26 Cortlandt St., N. Y. 35 Gt. Dover St., S. E., London. Bourse Building, Philadelphia.
316 Magazine St., New Orleans. Puente de San Francisco, No. 6 Mexico City.

ONE OF OUR ADVERTISEMENTS OF THREE DECADES AGO

The "Clip" in 1900

FIELD SINCE 1862

In "POWER" since 1887

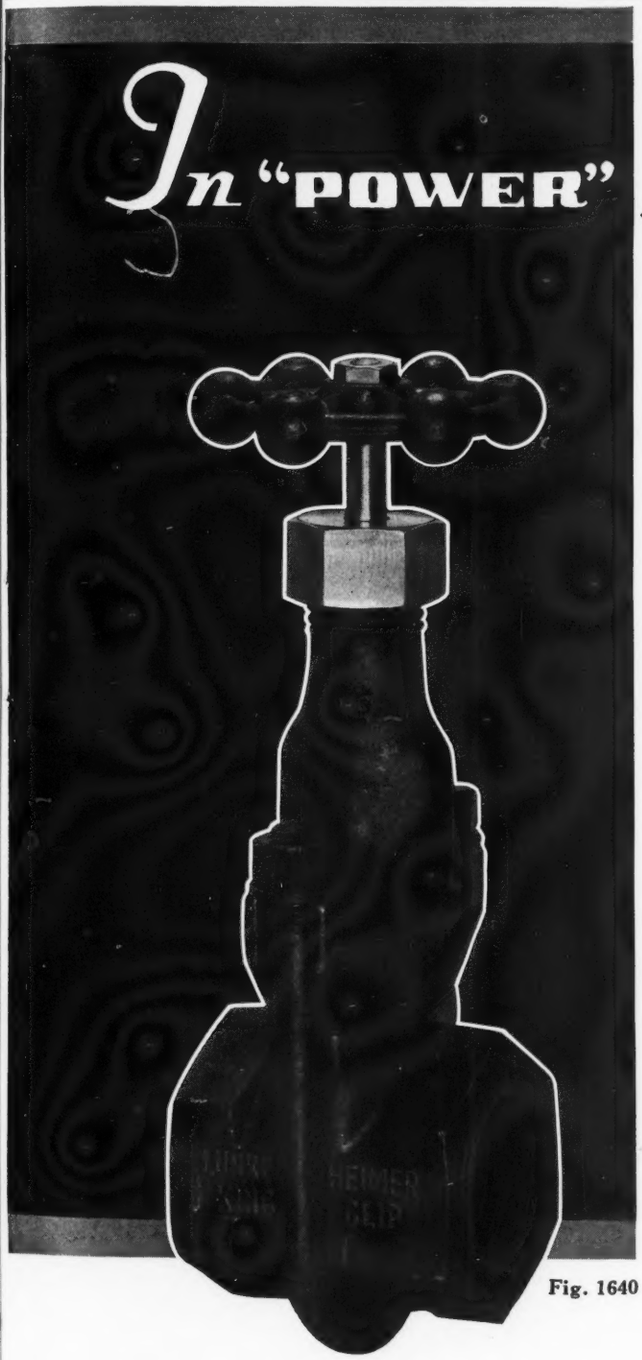


Fig. 1640

The "King-Clip" of Today

Patented 1931

For more than 70 years the name Lunkenheimer has been synonymous with quality in valves. Grandfathers of present day engineers knew and trusted Lunkenheimer Valves.

The Lunkenheimer Company has grown with the development of the use of steam for power and has kept pace with constantly increasing pressures and temperatures, successfully furnishing at each step improved valves of a quality worthy of the name Lunkenheimer.

Lunkenheimer products are built to one standard—the finest quality consistent with practical results. This high standard is demonstrated by the installations of Lunkenheimer Valves in leading plants throughout the country—from the largest central station to the small successful industrial plant.

Lunkenheimer products are available in all industrial centers through an extensive organization of representative distributors.

THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO BOSTON
PHILADELPHIA SAN FRANCISCO
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

LUNKENHEIMER VALVES

KELLOGG STANDARDS DICTATED THEIR SELECTION

Kellogg equipment installed in the power plants selected as representative of the best power plant practice in 1934 includes:

KELLOGG—Fabricated high pressure piping—plain and corrugated

KELLOGG—"Masterweld" steam and boiler feed headers

KELLOGG—"Masterweld" boiler drums and steam domes

KELLOGG—Corrugated bends and tangents

KELLOGG—"Masterweld" high pressure feed water storage receivers

For over twenty-five years the M. W. Kellogg Company has been designing, fabricating and installing quality equipment for the outstanding power plants of this country.

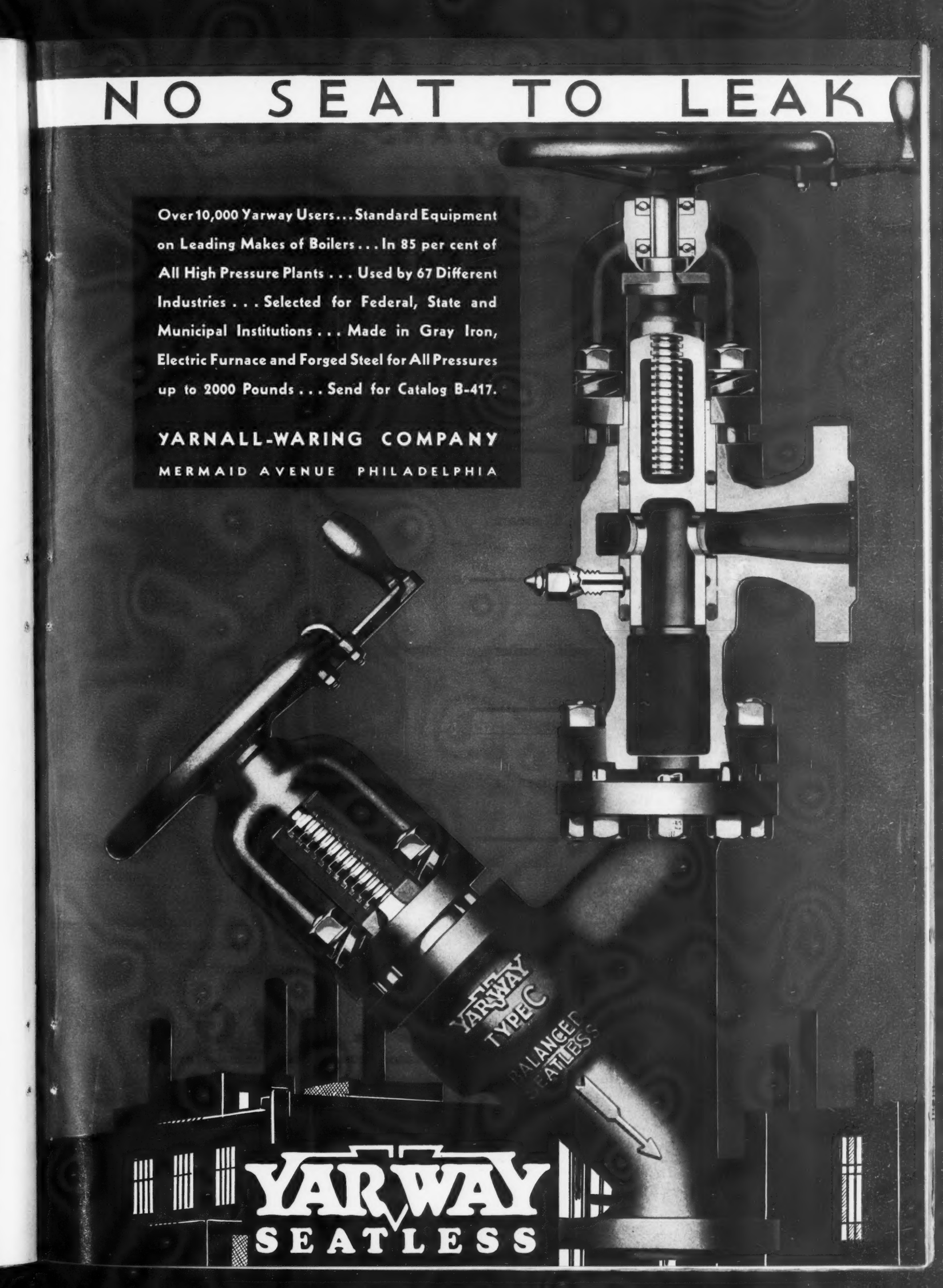
KELLOGG

THE M. W. KELLOGG COMPANY · 225 BROADWAY, NEW YORK

Chicago, 1 La Salle St · San Francisco, 200 Bush St · Tulsa, Philtower Building
Birmingham, 827 Brown-Marx Building · Los Angeles, 1031 South Broadway

Pressure vessels "Masterweld" for the Power, Refinery and Chemical Industries. Power Plant and Industrial piping. Heat Exchangers. Radial Brick Chimneys, Plastic Refractories. Cross, Holmes-Manley, de Florez and Tube and Tank cracking units, absorption plants and pipe stills.

NO SEAT TO LEAK



Over 10,000 Yarway Users... Standard Equipment on Leading Makes of Boilers... In 85 per cent of All High Pressure Plants... Used by 67 Different Industries... Selected for Federal, State and Municipal Institutions... Made in Gray Iron, Electric Furnace and Forged Steel for All Pressures up to 2000 Pounds... Send for Catalog B-417.

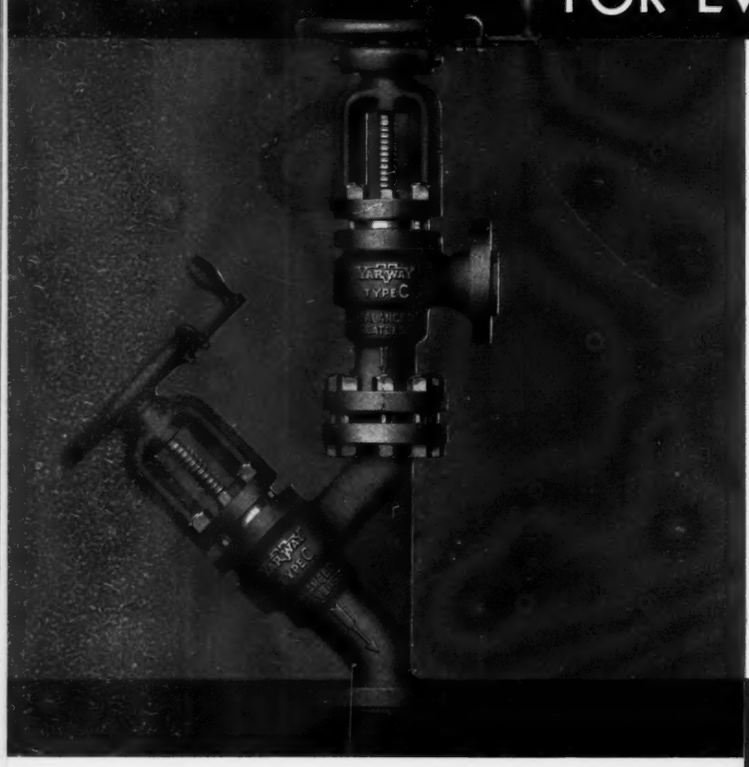
YARNALL-WARING COMPANY

MERMAID AVENUE PHILADELPHIA

YARWAY

SEATLESS

YARWAY BLOW-OFF VALVES FOR EVERY PRESSURE AND PURSE



900 POUNDS W.S.P.—Fig. No. 3922-20, illustrated at left. Yarway Type C Seatless Blow-Off Valve, Angle Type, with operating handle and planetary gear operation, in tandem with direct-acting straightway Type C valve. Both valves have extra heavy steel bodies and yokes, with bronze, nickel alloy or nitralloy mountings. Made in 2½" size only.

This same steel Tandem with both valves direct acting is made in 1½", 2" and 2½" sizes.

600 POUNDS W.S.P.—Fig. No. 3910-12. Similar in general design to the Yarway Tandem described above, but with steel bodies and yokes not quite so heavily constructed. Both valves of direct-acting type. Made in 1½", 2" and 2½" sizes.

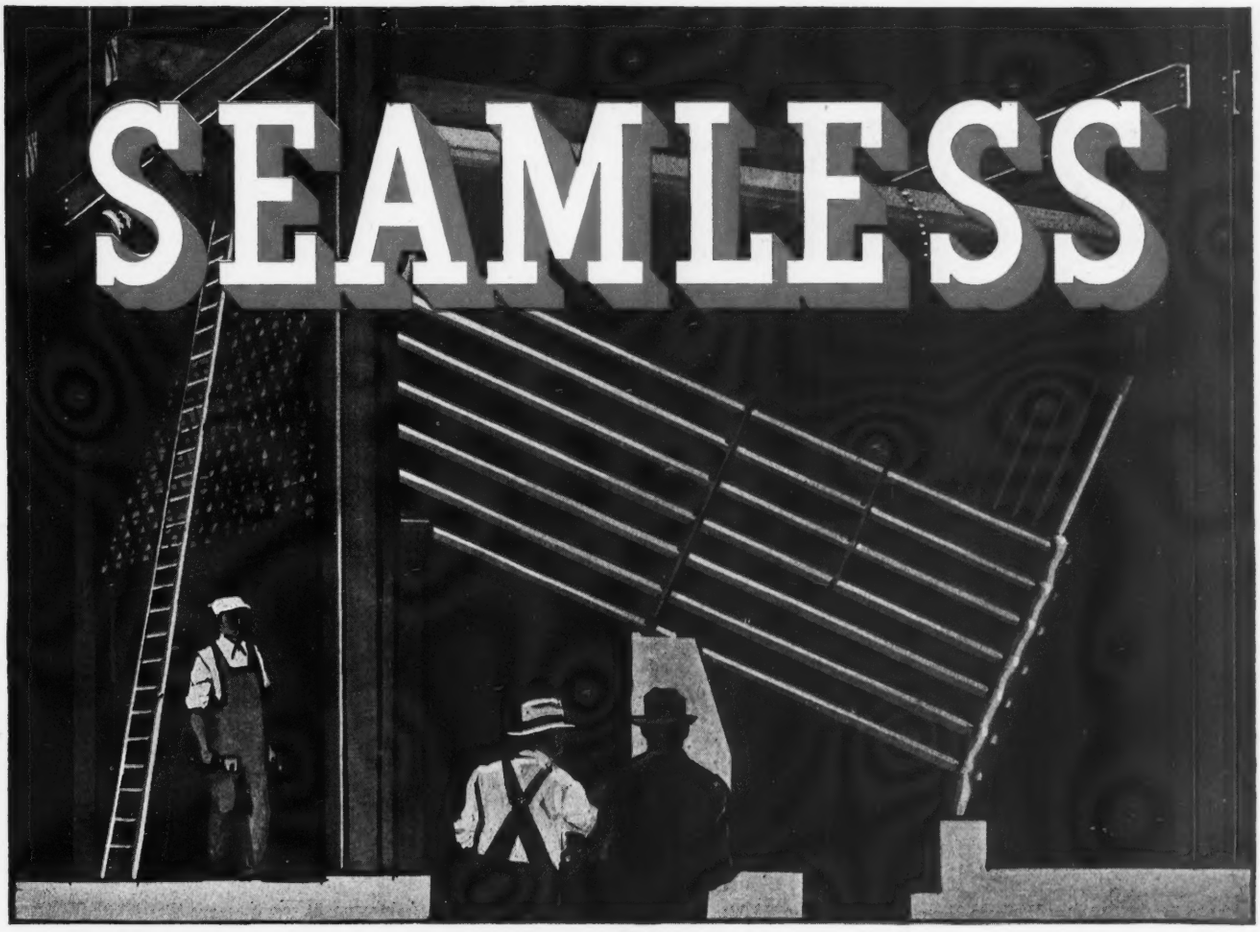
400 POUNDS W.S.P.—Fig. No. 3496-88 illustrated at right. Yarway Type B Balanced Seatless Valve with operating handle and planetary gear operation in tandem with a Type B straightway direct-acting valve. Both valves have steel bodies and yokes and bronze or nickel-alloy mountings. Made in 2½" size only.

This same steel tandem, without planetary gear operation, is known as Fig. No. 3486–88. Made in 1½", 2" and 2½" sizes.

Offered in iron with bronze or nickel alloy mountings for pressures up to 250 pounds, it is known as Fig. No. 3482-84. Made in 1½", 2" and 2½" sizes.

250 POUNDS W.S.P.—Fig. No. 3482-48 illustrated at left. Yarway Type B Balanced Steel Valve in tandem with Yarway Gear-Operated Double Tightening Valve. Both valves have iron bodies and bronze mountings. This same tandem is also supplied with double-tightening valve of direct-acting type, Fig. No. 3482-46, for lower pressure power and heating service. Both Tandems are made in sizes 1½" to 4" inclusive.

YARNALL-WARING COMPANY, MERMAID AVENUE, PHILADELPHIA



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Rolled from a solid billet, there can be no weak spots in **J&L** Hot Rolled Seamless Steel Boiler Tubes. Since there is no joining of metal, there are no welds to open under the stress of service. Strength is *inherent* in the **J&L** seamless process. **J&L** Boiler Tubes comply with all recognized specifications. Furnished in a full range of standard sizes, from 1" O.D. to 6" O.D. inclusive.

Write for further information.

J&L PIPE

JONES & LAUGHLIN STEEL CORPORATION

AMERICAN IRON AND STEEL WORKS

JONES & LAUGHLIN BUILDING, PITTSBURGH, PENNSYLVANIA

Sales Offices: Atlanta Boston Buffalo Chicago Cincinnati Cleveland Dallas Denver Detroit Erie Los Angeles Memphis Milwaukee Minneapolis New Orleans New York Philadelphia Pittsburgh St. Louis San Francisco

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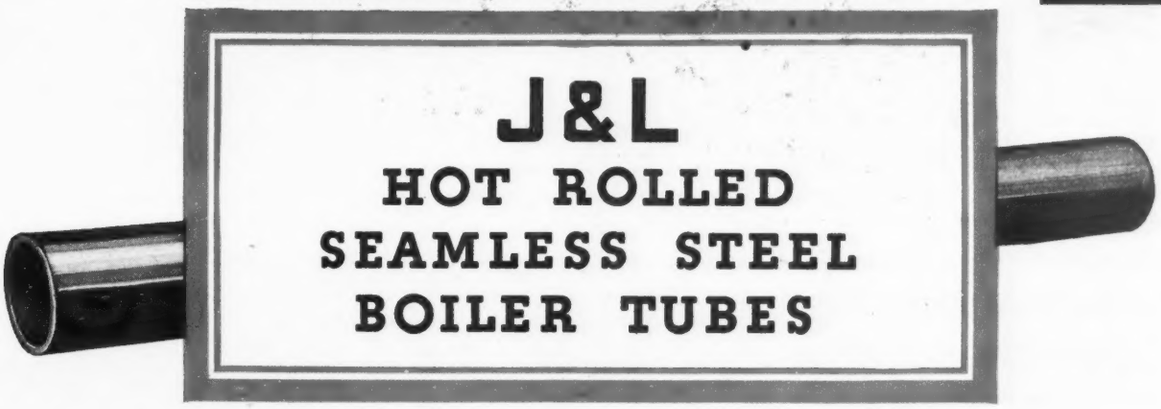
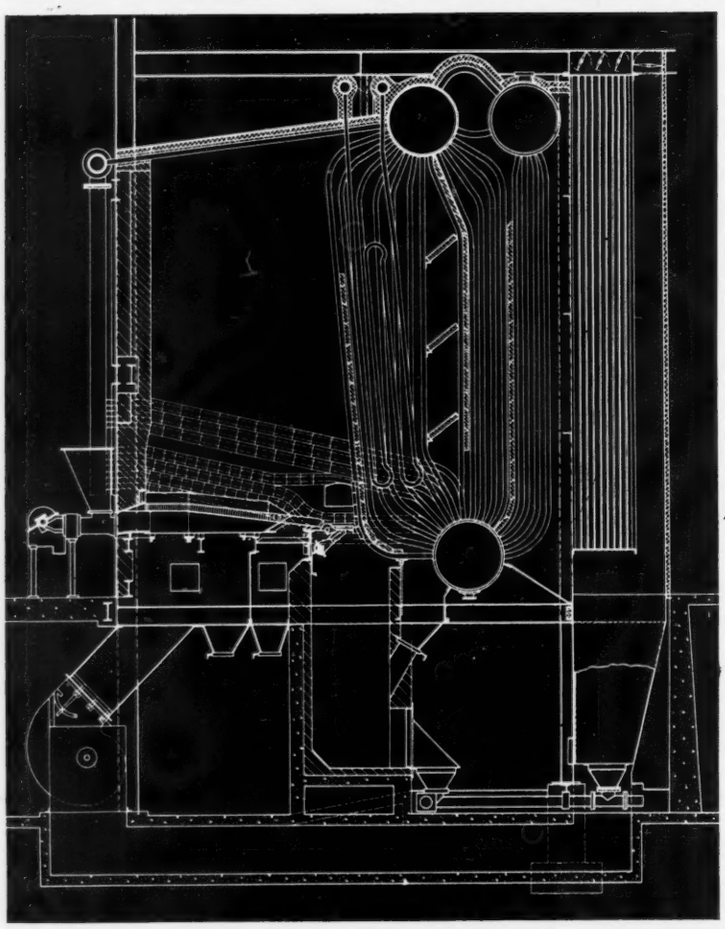
Canadian Representatives: JONES & LAUGHLIN STEEL PRODUCTS COMPANY, Pittsburgh, Pa., U. S. A., and Toronto, Ont., Canada

J&L STEEL



DETROIT STOKER APPLICATIONS



● Here you see a few recent and modern applications of Detroit Stokers to boilers of various types and sizes. Similar drawings are also available showing how Detroit Stokers have been applied to practically all other types of boilers burning a wide variety of coals.

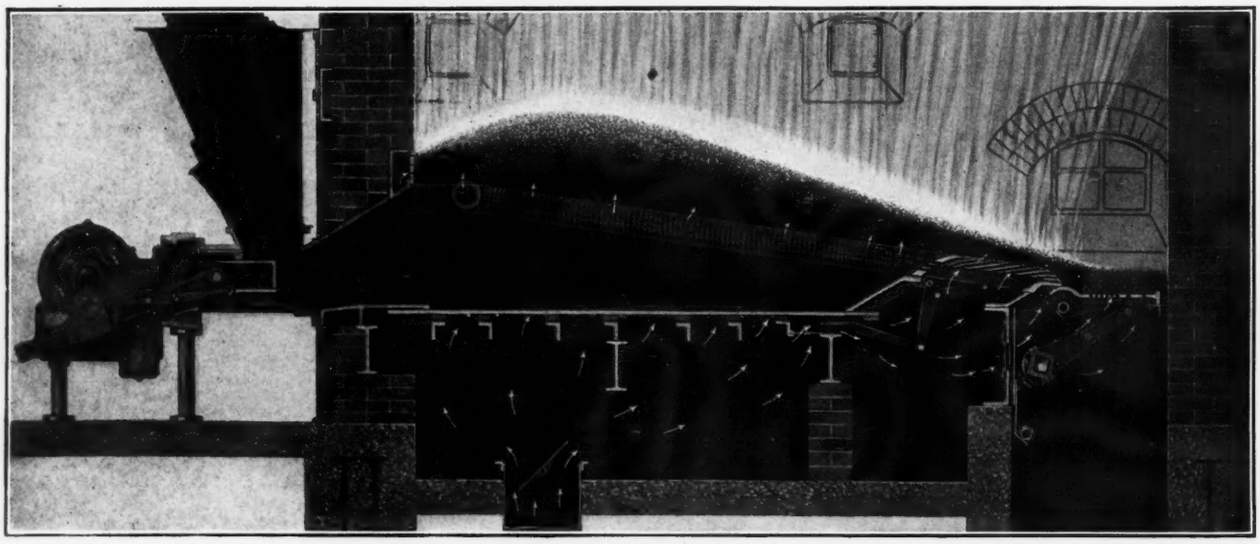
● One important factor in the outstanding success of Detroit Stoker installations is the wide experience of over thirty years of specialization in the *correct* application of stokers to all types of boilers operating under all load conditions. After all, there is no substitute for experience.

● Detroit Stokers are self-liquidating investments . . . they quickly pay for themselves out of the savings they make. We will submit reports of reductions in steam cost that Detroit Stokers have made in plants similar to yours. Write for Bulletin 830.

DETROIT STOKER COMPANY

Sales Offices and Engineering Department:
Third Floor, General Motors Building, Detroit, Michigan
Works at Monroe, Mich.—District Offices in Principal Cities
BUILT IN CANADA AT LONDON, ONTARIO

At Left—Detroit Stoker with vertical bent tube boiler for 300 pounds pressure and 150 degrees superheat. Built to operate continuously with 300 degrees preheated air, at 250% of rated boiler capacity. This is the third contract for Detroit Stokers from the Theodore Hamm Brewing Company, St. Paul, Minn. Repeat orders are indisputable proof of satisfactory operation.

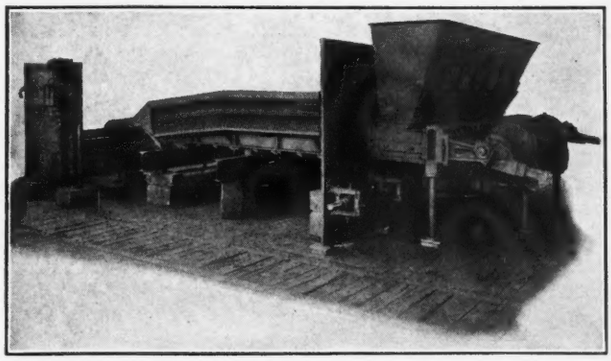


Above—Sectional side elevation of Detroit Stoker showing inclined fuel bed with complete underfeed action, correct air distribution by zones and easy adjustment of coal feed and distribution.

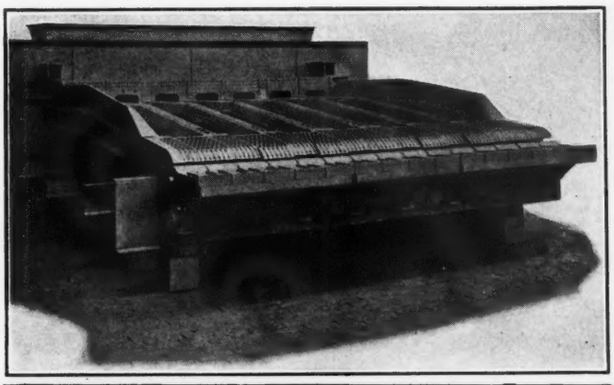
MODERNIZE AND ECONOMIZE WITH

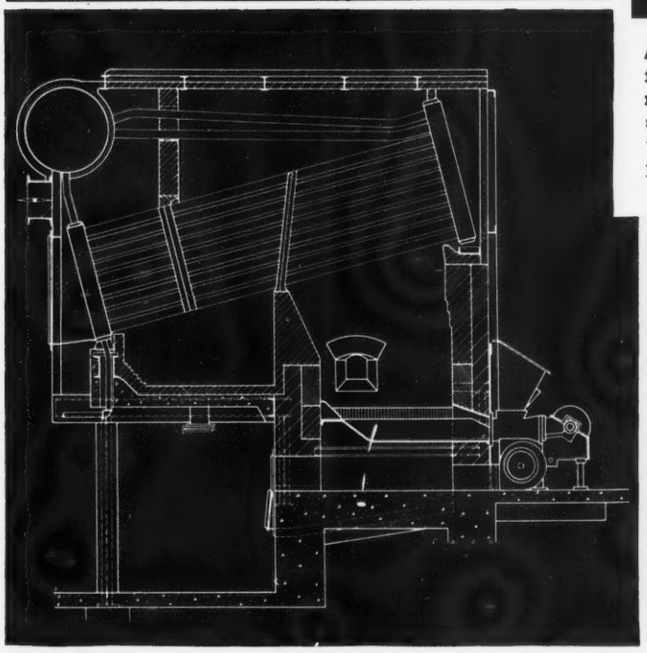
DETROIT

FOR MODERN BOILER SETTINGS

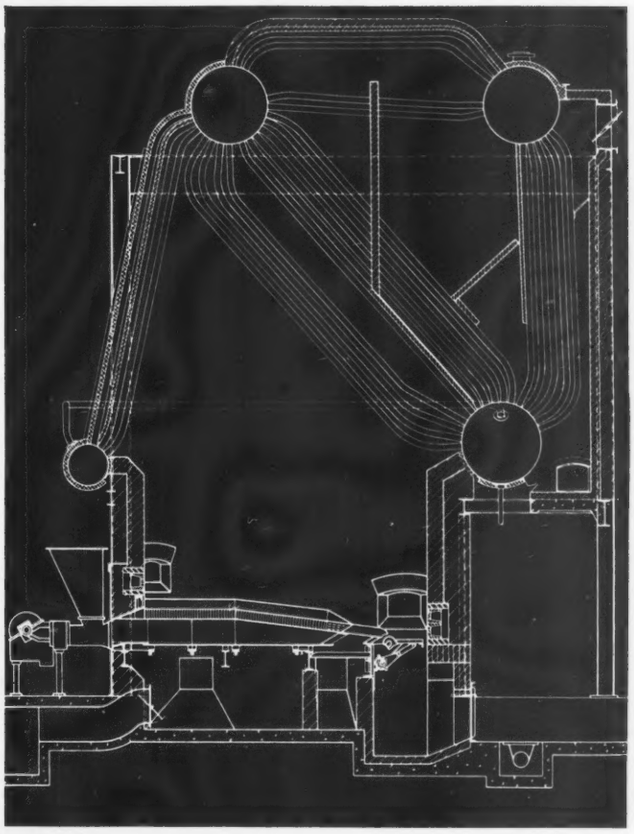


Above and Below—Note the rugged construction of the Detroit Stoker, heavily built for continual hard service.

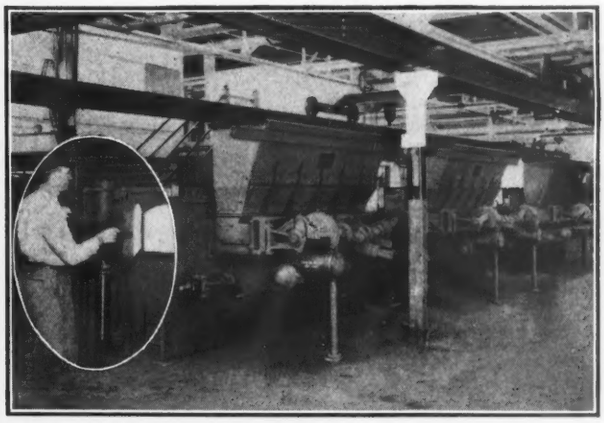




Above—Detroit UniStoker (turbine driven) with cross drum boiler. This stoker is side cleaning; ash removal may be at the front or rear as shown. State of Delaware Old Age Welfare Home.



Above—Detroit Stoker with four drum bent tube boiler designed for 300% of rated capacity. Note the unique arrangement of ash removal at the rear without basement or tunnel. This is the second contract for Detroit Stokers from the Textileather Corporation, Toledo, Ohio. Repeat orders are the result of satisfactory performance.



Above—This photograph shows the assembly floor where Detroit Stokers are completely assembled and inspected before shipment. The insert illustrates how movement of power dump can be observed during operation.

STOKERS

QUALITY STOKERS SINCE 1898

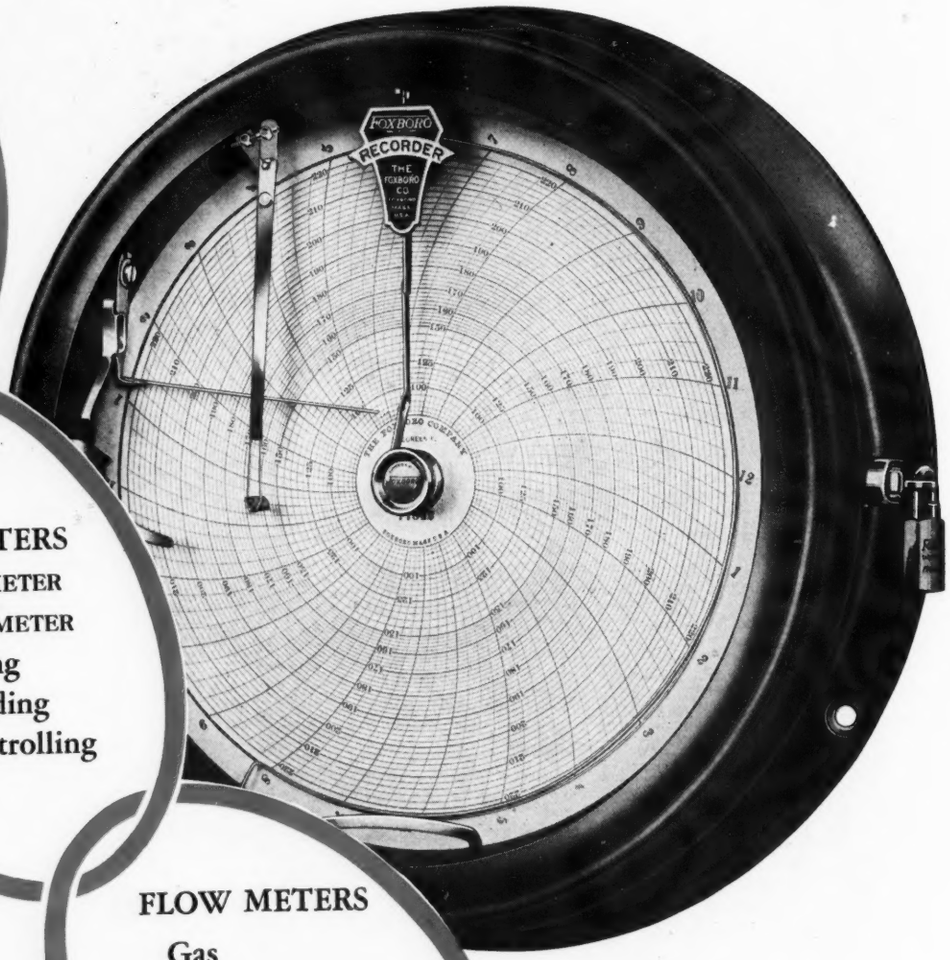
remember these two big facts

1

2

INSTRUMENTS FOXBORO Gives

CONTROLLERS
Temperature
Pressure
Liquid Level
Humidity
Flow



PYROMETERS
POTENTIOMETER
MILLIVOLTMETER
Indicating
Recording
Controlling

FLOW METERS
Gas
Oil
Water
Steam
Air

THERMOMETERS
Pressure Type
Resistance Type
Recording
Dial Type

FOXBORO
REG. U. S. PAT. OFF.

The Most Complete line of Instrument Control for Industrial Processes

SAVE MONEY QUICKLY

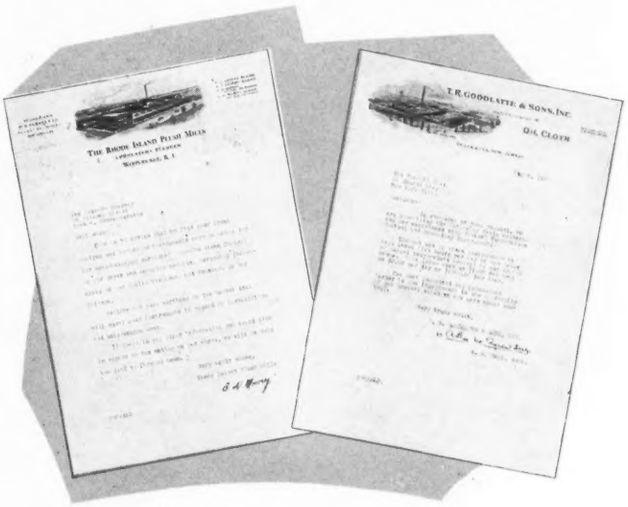
You Maximum Savings

There is probably no quicker way of making immediate savings than by the use of instruments. Especially is this true today when quality is threatened by shorter hours, new and untrained employees and generally higher costs. Correct use of instruments will increase quality at a reduction in cost.

Foxboro Recording Instruments, furnishing an accurate check on processes, quickly spot the places where improvements will cut waste. Foxboro Automatic Control will result in maximum production at uniformly high quality.

Because Foxboro has the correct instruments for every individual problem, maximum savings are possible in every case. You need not use an instrument ill-adapted to the range or conditions you have. Correct manufacture also results in maximum use even under the worst conditions.

If you want to cut costs—consult Foxboro on your process problems.



EVIDENCE . . .

A great many manufacturers have written enthusiastic letters about the results they get from Foxboro Instruments. These letters give evidence of money-saving ability and long, useful life.

If you need more evidence, write to us today for complete facts.

The NEW FOXBORO RECORDER

The new round chart Foxboro Recorder is a fine example of quality and present-day economics.

By redesigning each part to fit its use exactly, this Recorder has been made by far the most convenient instrument to use. It is easier to change charts, to ink pens, to clean and take care of the instrument. Where any number of instruments are used, the much lower maintenance cost of the Foxboro Recorder is an important item.

Ask to see one of these new Foxboro Recorders. They are made for temperature, pressure, humidity, flow and liquid level.

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THE COMPASS OF INDUSTRY

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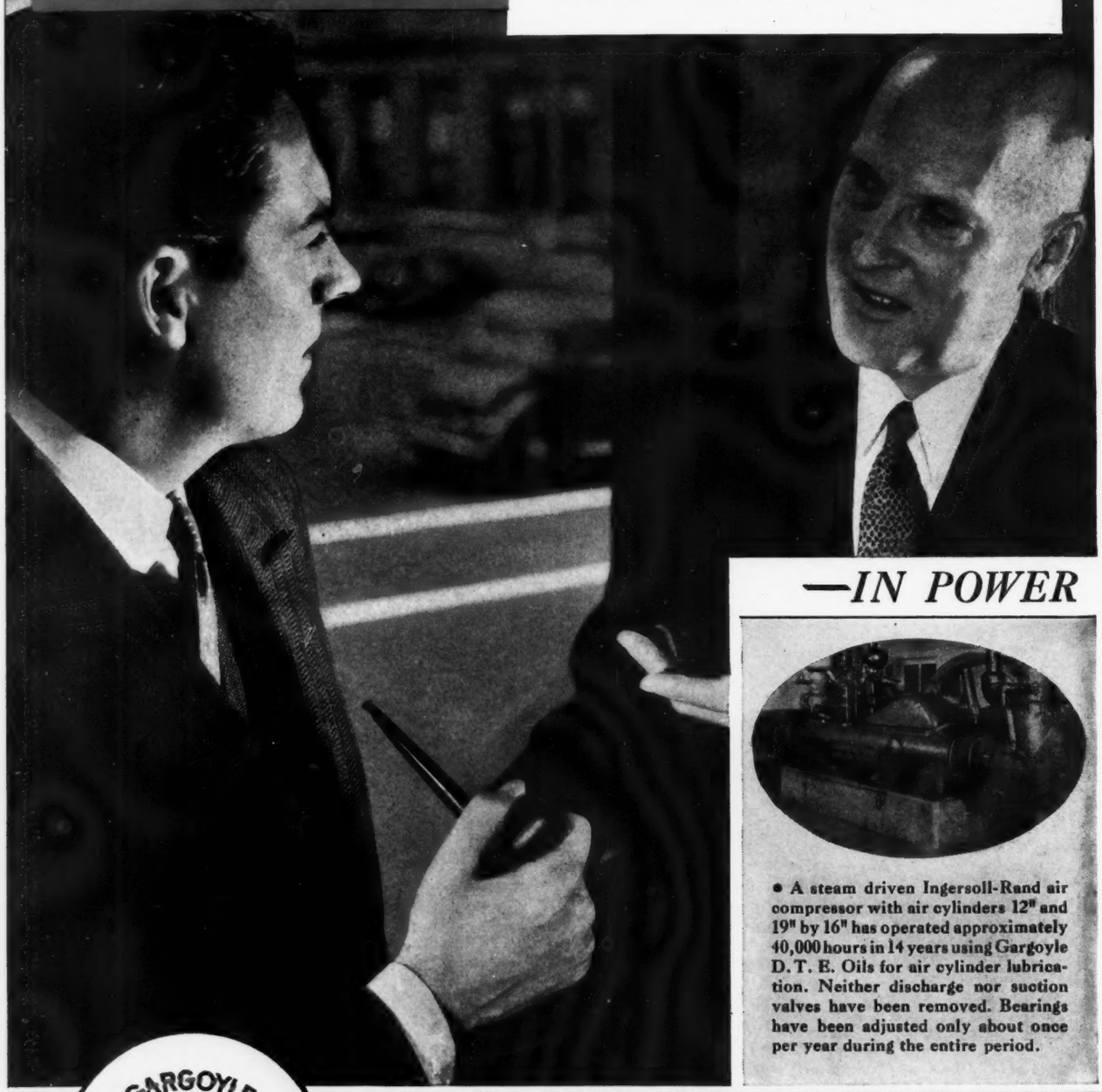
"I CAN BUY OILS FOR LESS PER GALLON!"

"SURE!...AND SKYROCKET YOUR POWER AND MAINTENANCE COSTS!"



—IN POWER

• A steam driven Ingersoll-Rand air compressor with air cylinders 12" and 19" by 16" has operated approximately 40,000 hours in 14 years using Gargoyle D. T. E. Oils for air cylinder lubrication. Neither discharge nor suction valves have been removed. Bearings have been adjusted only about once per year during the entire period.

GARGOYLE

Lubricating Oils

SOCONY-

CORPOR

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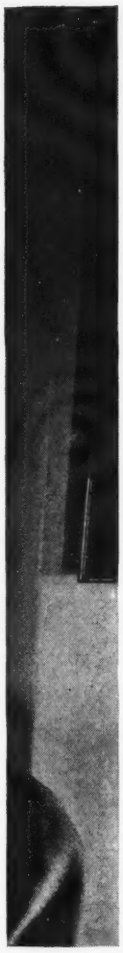
REFINING CORPORATION • WHITE EAGLE OIL CORPORATION • MAGNOLIA



You can't Specify *Lubricating Ability* in an Oil—

Industrial case histories show four ways in which Gargoyle Lubricants save their own cost

●When you buy oil, you do not buy merely the oil itself, but the ability of the refiner to obtain the greatest amount of performance value from his crudes.

After 68 years of intensive study of lubrication in all its phases, Socony-Vacuum, with the intimate knowledge acquired through long experience, has been able to make oils and greases that prove maximum lubricating ability in any fair test.

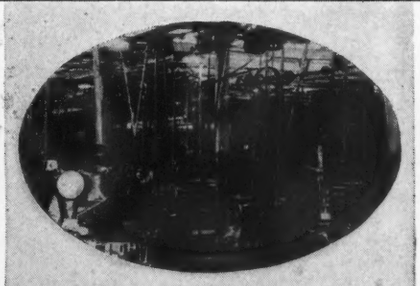
In lubricants and in the art of lubrication, Socony-Vacuum offers service values that are doubly important because they show up in actual plant operation as well as in laboratory tests.

The "case histories" below show four ways in which Socony-Vacuum Lubricants give improved lubrication, often with operating economies that pay the oil bill.

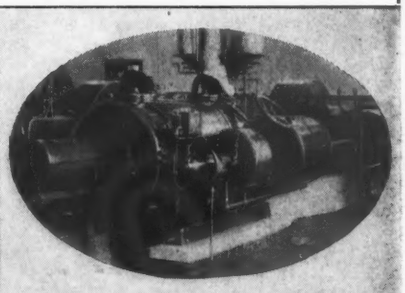
PLANT SERVICE IT'S PERFORMANCE THAT COUNTS

• A 15,000 kw. steam turbine was placed in service with 800 gallons of Gargoyle D.T.E. Oil Light.

After three years in service, with a few hours DeLaval centrifuge treatment every three days and an average make-up of 10 gallons per month, laboratory test showed the oil still in good condition for continued use.



• When Gargoyle Vactra Oil Heavy Medium X replaced "specification oil" on line shaft driven machines in an Ohio plant, test charts showed a reduction of 12% in the total load, 12% in line shaft friction, and 12% to 17% in individual machine friction loads. The power saving is in excess of the total oil cost of the department.



• Two uniflow engines in a Michigan plant had been running daily for nine years using Gargoyle Cylinder Oil 600W. At the end of that time the builder's representative inspected the engine which had the most service and reported that, although it sometimes ran as much as 24 hours a day, hardly any wear had taken place.

VACUUM
ATION

WADHAMS OIL COMPANY • WHITE STAR REFINING COMPANY • LUBRITE PETROLEUM COMPANY • GENERAL PETROLEUM CORPORATION OF CALIFORNIA

NEW
Gargoyle Greases · Gargoyle Super-Cylinder Oil 600W Cutting and Soluble Oils

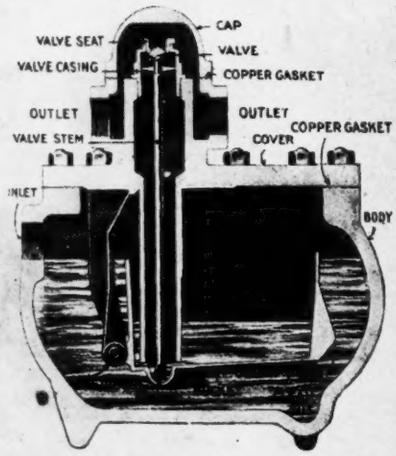
TWENTY-FIVE YEARS AGO

(July 1909)

our first advertisement appeared in POWER

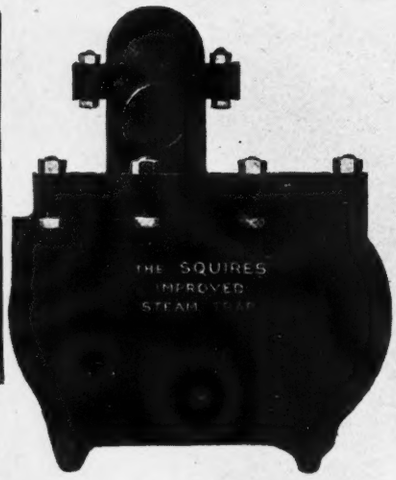
July 6, 1909. POWER AND THE ENGINEER. 137

SQUIRES STEAM SPECIALTIES



THE
Squires
Traps
For Service

Write for Catalog and Factory Prices



We are the Inventors, Manufacturers and Sole Agents of

THE SQUIRES

Steam Traps, Reducing Valves, Pump Governors, Boiler Feed-Water Regulators, Open Feed-Water Heater Controllers, etc.

The C. E. Squires Co.

1426 West 3rd Street

Cleveland, Ohio

SQUIRES STEAM SPECIALTIES

TODAY—

Genuine Squires Steam Traps and Steam Specialties are still a "Standard" in the Power Field

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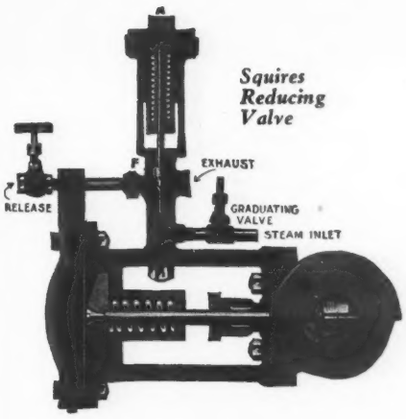
Squires steam, air and blast traps—reducing valves—pump governors—feed water controllers—have been a standard of reliability for 35 years.

For 25 years of those 35 years we have been advertisers in Power. Today, more than ever, Squires traps and steam specialties stand out as simple, durable, economical, efficient devices upon which the engineer can rely.

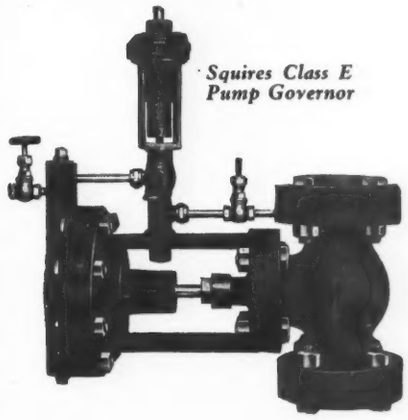
Leading companies everywhere use Genuine Squires Traps, because the same good principles that made them reliable have not been deviated from. Note how easily and quickly a valve and seat may be replaced for any other desired pressure.

Squires Reducing Valves will reduce from any pressure to atmospheric in one reduction. No need of secondary valves. They are dead end valves.

Write for literature A-2.



Squires Reducing Valve



Squires Class E Pump Governor

Squires Boiler Feed Water Controller

Insist on the Genuine **Squires** Steam Specialties

THE C. E. SQUIRES COMPANY

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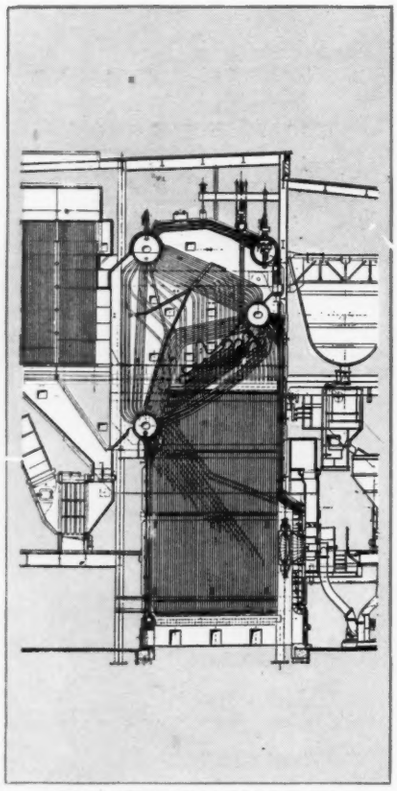
A Page of America's Recent Outstanding



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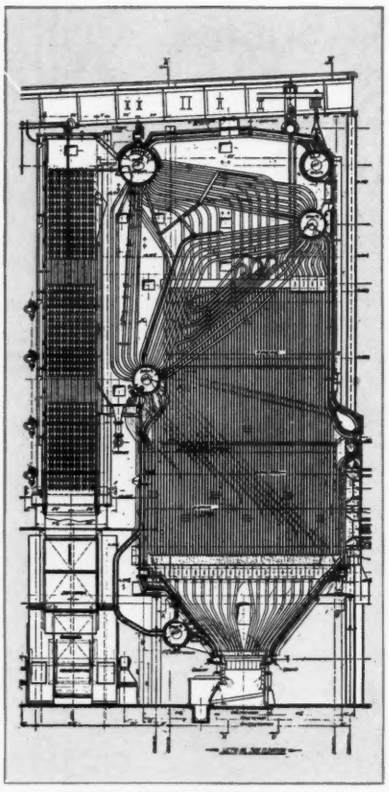
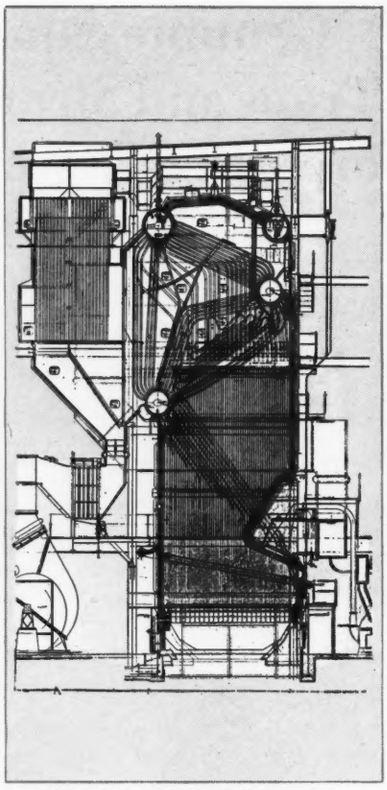
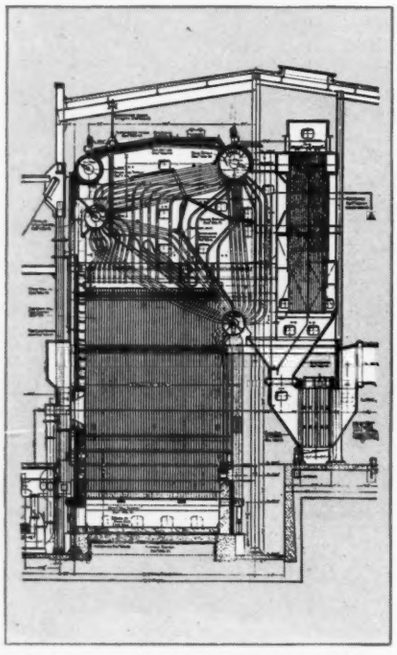
Covington, Va.
375,000 lbs. of steam per hour
600 lbs. pressure—750°F steam
Riley Steam Generating Unit



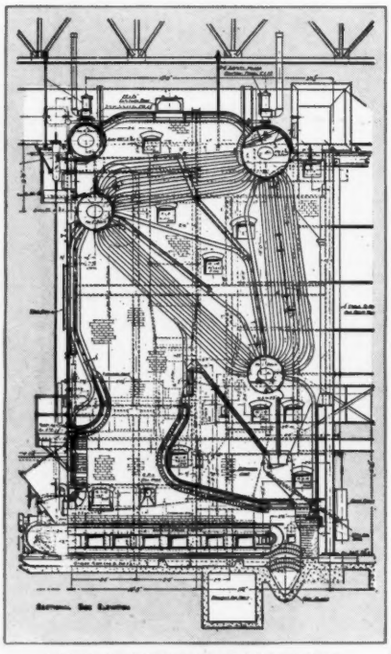
LARGE EASTERN OIL REFINERY
300,000 lbs. of steam per hour
650 lbs. pressure—740°F steam
Riley Steam Generating Unit



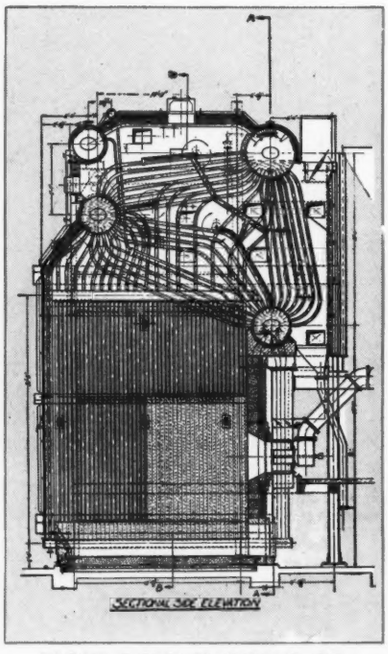
W. VA. PULP & PAPER CO.
Piedmont, W. Va.
375,000 lbs. of steam per hour
630 lbs. pressure—750°F steam
Riley Steam Generating Unit



Kalamazoo Vegetable Parchment Co.
Kalamazoo, Mich.
150,000 lbs. of steam per hour
275 lbs. pressure—650°F steam
Riley Steam Generating Unit



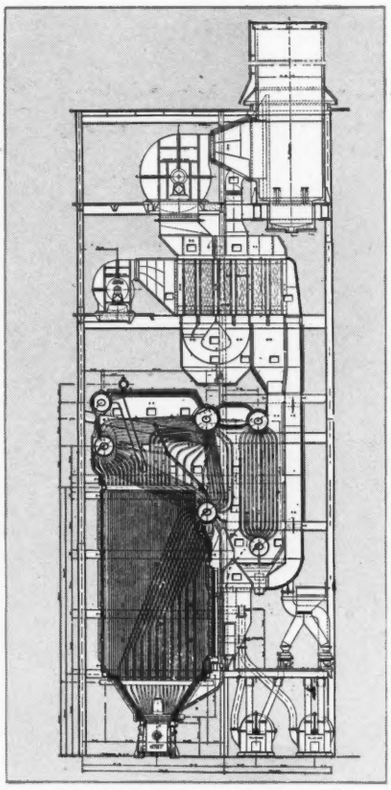
FINCH PRUYN COMPANY
Glens Falls, N. Y.
50,000 lbs. of steam per hour
140 lbs. pressure
Riley Steam Generating Unit



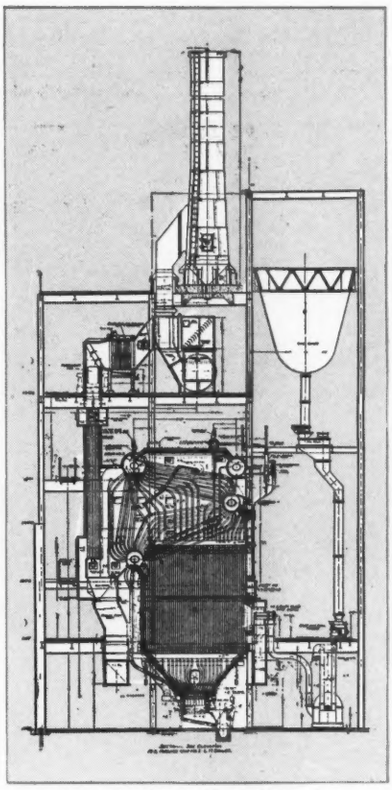
JACOB DOLD PACKING CO.
Buffalo, N. Y.
67,000 lbs. of steam per hour
275 lbs. pressure—514°F steam
Riley Steam Generating Unit

WRITE RILEY STOKER CORPORATION, Worcester, Mass., for 1/8" scale drawings and further infor-

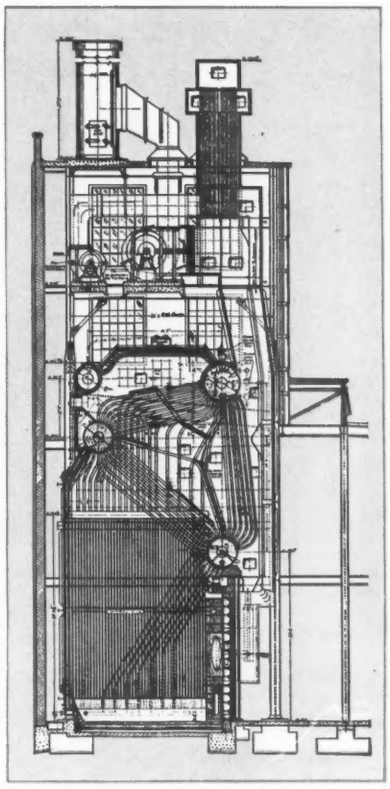
Installations of Steam Generating Units



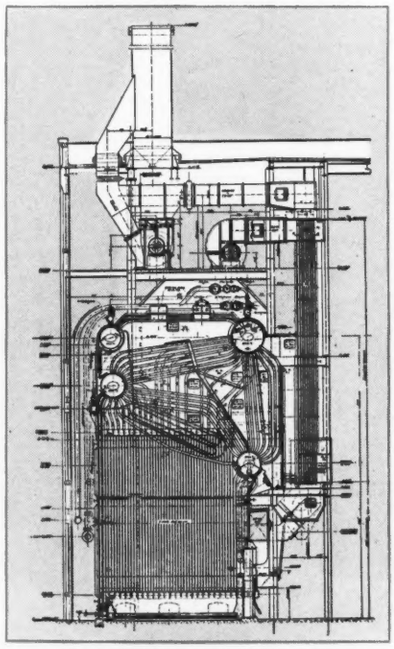
PENNSYLVANIA SUGAR CO.
Philadelphia, Pa.
300,000 lbs. of steam per hour
450 lbs. pressure – 505°F steam
Riley Steam Generating Unit



FORSTMANN WOOLEN CO.
Garfield, N. J.
80,000 lbs. of steam per hour
450 lbs. pressure—612°F steam
Riley Steam Generating Unit



CONTINENTAL DISTILLING CO.
Philadelphia, Pa.
100,000 lbs. of steam per hour
250 lbs. pressure
Riley Steam Generating Unit



GENERAL ANILINE CO.
Grasselli, N. J.
65,000 lbs. of steam per hour
450 lbs. pressure – 670°F steam
Riley Steam Generating Unit

mation about any of these plants

*I*F YOU WANT to see steam generated as it should be and steam generating equipment built as it should be built, visit any of the above installations of Riley Steam Generating Units. It will certainly pay you to visit one or more of these plants if you are considering the installation of modern boiler equipment.

If you make this visit, you will find steam generating equipment which more than meets today's demand for extreme economies in the generation of steam. You will find outstanding performance, complete satisfaction, trouble-free operation and a minimum of maintenance. You will be attracted by the excellent appearance and general layout of the units.

It will then be apparent to you why there has been such a definite swing during the past few years to Riley Steam Generating Equipment. In spite of general business conditions, sales of Riley Steam Generating Units in 1932 were greater than in 1931, and 1933 sales more than doubled 1932 sales.

It will pay you well to investigate Riley Steam Generating Units when modernization of your boiler plant is considered.

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WORCESTER, MASS.

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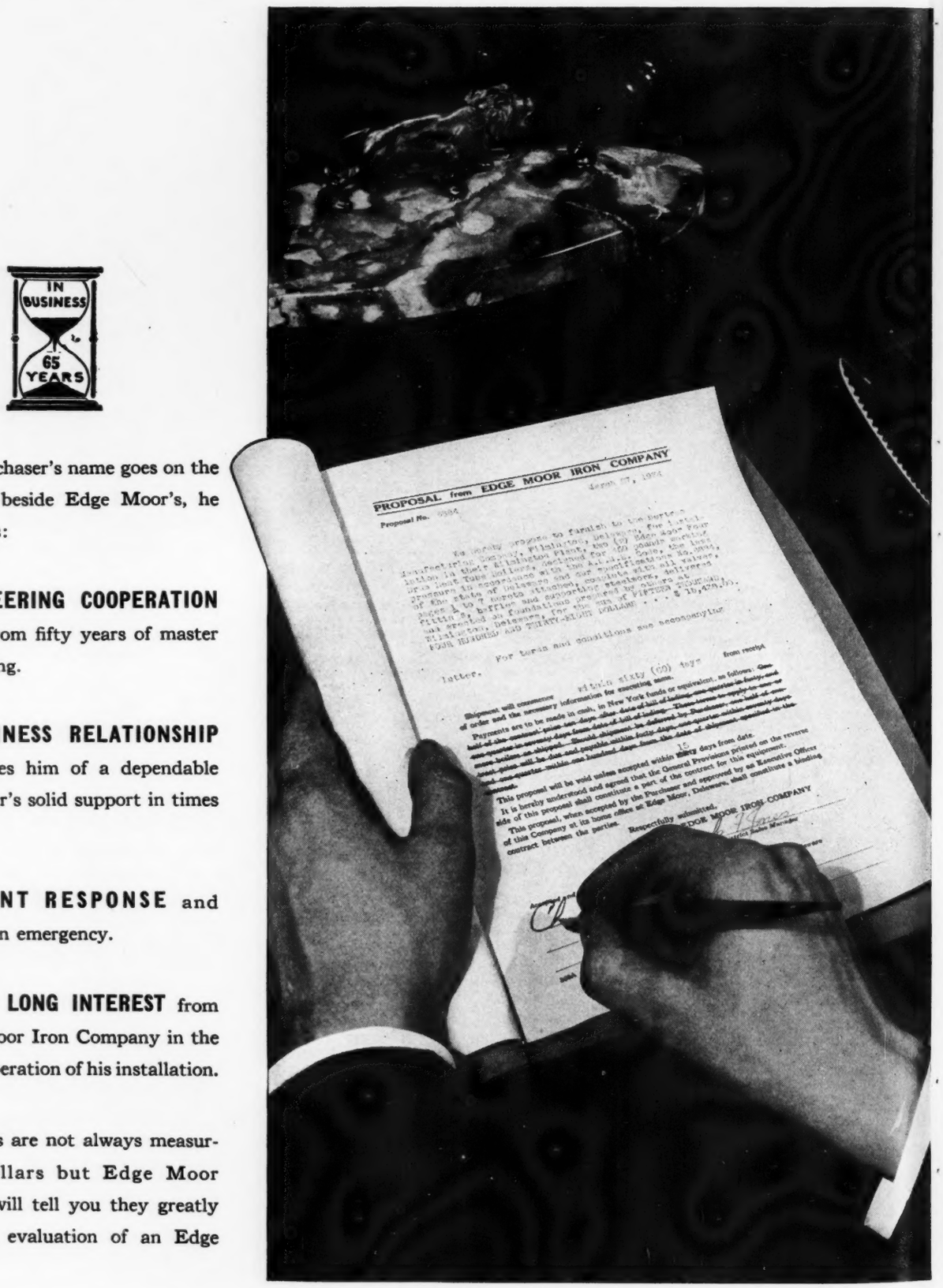

When a purchaser's name goes on the dotted line beside Edge Moor's, he also acquires:

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2. A BUSINESS RELATIONSHIP which assures him of a dependable manufacturer's solid support in times of stress.

3. INSTANT RESPONSE and helpfulness in emergency.

4. A LIFE LONG INTEREST from the Edge Moor Iron Company in the successful operation of his installation.

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DE LAVAL was a pioneer in the invention and perfection of the steam turbine, in high pressure steam, and in the use of the helical speed reducing gear.

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In 1894 he patented the diverging steam nozzle.

In 1897 he operated at the Stockholm Exposition six geared turbine generating units under steam pressures of 1400 to 3000 lb. and at 750° F.

In 1907 he designed a triple expansion turbine with two-pinion, double helical gear for ship propulsion.

●

The De Laval Steam Turbine Company was established in America in 1901 and has introduced REVOLUTIONARY IMPROVEMENTS in:

CENTRIFUGAL PUMPS

CENTRIFUGAL BLOWERS and COMPRESSORS

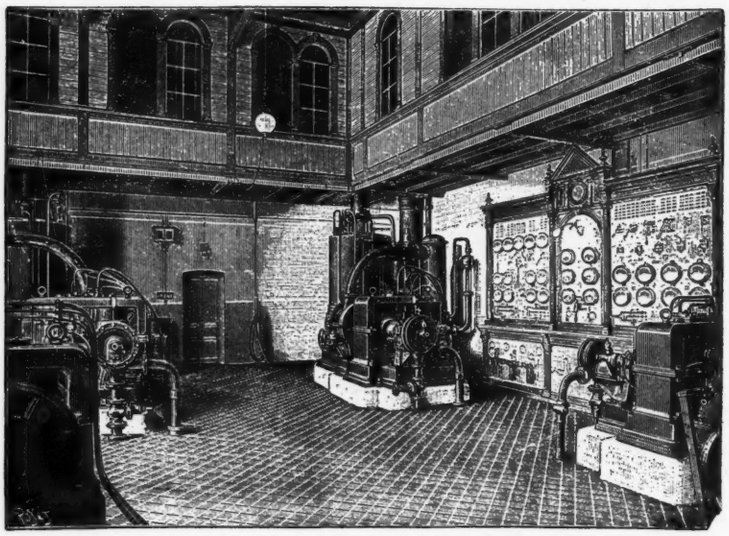
SPEED REDUCING GEARS (of both helical and worm types)

GEARED TURBINES for generator and pump drives and for ship propulsion

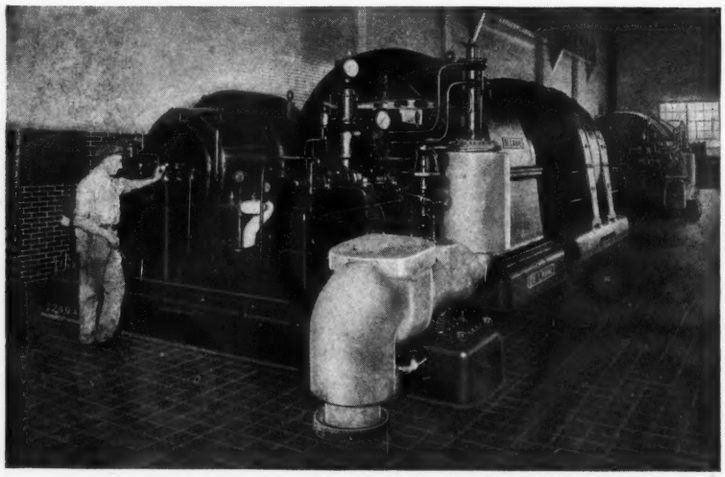
ROTARY DISPLACEMENT PUMPS for motor and turbine speeds and pressure up to 500 lb. and over

PROPELLER PUMPS for delivering large volumes against low heads at motor and turbine speeds, and

THE BAUER-WACH EXHAUST TURBINE SYSTEM for rejuvenating marine power plants.



De Laval 3000 lb. steam pressure geared turbo-generators in 1897 Stockholm Exposition.



One of eight De Laval 4000 kw. geared turbine house generator units installed by a large Edison Company.

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The De Laval Company has also perfected the PRODUCTION OF STEAM PLANT EQUIPMENT ON A LIMIT GAGE BASIS to insure interchangeability and quick replacements, which, together with skillful design and the use of the best materials, results in low cost of upkeep.

EFFICIENCIES and other characteristics, as also perfect functioning, are GUARANTEED and are demonstrated by tests at the works.

DE LAVAL STEAM TURBINE CO., TRENTON, N. J.

3166

Fiftieth Anniversary

POWER

Volume 78
Number 6

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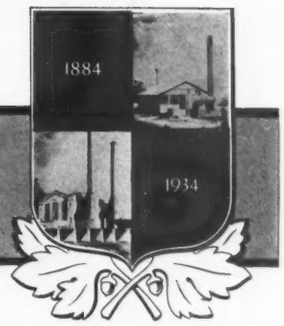

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•

WE PAUSE TO THANK—

IN PREPARATION of such a number as this, almost innumerable sources, companies and individuals must be consulted. *Power* has been exceedingly lucky in the painstaking cooperation of many distinguished authorities and through access to many standard works. In writing "The Story of Power," for example, almost a hundred sources were consulted, among them being these of particular value: "The Growth of the Steam Engine"—Thurston, "Gas and Oil Engines"—Clerk, "The Quest for Power"—Vowles, "Behemoth"—Hodgins & Magoun, "American Diesel Engines"—Morrison, "Power Plant Engineering & Design"—Morse, "Introduction to Internal Combustion Engineering"—O'Sneedon, "High-Speed Diesel Engines"—Judge, "Steam Power and Internal Combustion Engines"—Craig & Anderson, "Heat Engines"—Moorfield & Winstanley, "Oil Engines"—Bird, "Engineering of Power Plants"—Fernald & Orrok, "Modern Diesel Engine Practice"—Adams, "Steam—Its Generation and Use"—Babcock & Wilcox, "Anecdotes of Steam Engines"—Stuart, "Water-Power Engineering"—Mead, "Machinery for Refrigeration"—Selfe, "Compressed Air and Its Applications"—Hiscox, "History of Engineering"—Fleming, "The Story of Electricity"—Martin & Coles, "The History of the Incandescent Lamp"—Howell & Schroeder.

Among individuals, the whole-hearted cooperation and assistance in checking historical facts of Geo. A. Orrok is outstanding, as are the suggestions of Charles E. Lucke, Orestes H. Caldwell, George H. Gibson, David Moffat Myers, William Shoudy, Alfred Vaksdal, C. Harold Berry, Lionel Marks, John Elsman, Francis J. Sill, Harry M. Spring, C. R. Reid, Guy B. Randall and others.

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In the McGraw-Hill organization and exclusive of the staff of *Power*, these individuals were notably helpful: B. Z. Reiter, art and layout; J. A. Lucas, photography; J. Holland, typography; Oliver Bell, printing.

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F. R. Low

To Fred R. Low, honored friend and guide of power engineers everywhere—observer and recorder of power progress for nearly half a century—editor and editor emeritus for forty-six years—POWER dedicates this, its Fiftieth Anniversary Number

● BORN IN 1884, *Power* this year celebrates its golden anniversary. This June number—devoted to the past, present and future of power generation—marks the event.

These have been full years. The power field, unlike many others, has never rested in an "established practice." Progress has been incessant, demanding eternal alertness of all who would move with it. In the past fifty years the whole face of civilization has been changed by the intensive development of power equipment, hookups, theory and operating methods. The dreamings of Sadi Carnot, scientific stunts of Michael Faraday and practical constructions of James Watt at last bear fruit of a thousand varieties until the head swims at the complexity of the power picture.

Today, thanks to modern energy technique, many millions of horsepower flow constantly to machines that do man's instant bidding—carry him through the sky, over land, over and under the ocean—free him of practically all the heavy labor involved in the production of countless necessities and luxuries. Thanks to power alone, man is at last physically free after a million years of slavery to his own muscles.

With these incalculable blessings we have the so-called "problems of the machine age," none of which are problems of machines themselves, but rather of human beings whose social sense has not kept pace with the development of machinery. To their solution the engineer must also contribute.

But the power engineer's primary job will always be, as it has been in the past, the production of more and better power services at constantly lowered cost. This task will make ever-growing demands on trained intelligence, and require a corresponding development of the services of the technical press.

This is a critical year. Quite apart from the fact that *Power's* golden anniversary falls in 1934, the times call for a pause to review the past, take stock of the present and lay plans for the future. Movement is not enough; in the light of all that man has done to and with power, we must learn where we are going and why. *Power* accepts this call and presents in this anniversary number a story of power generation sweeping from ancient times through the magnificent realities of the present to the thoughts and dreams of those who look to the future.

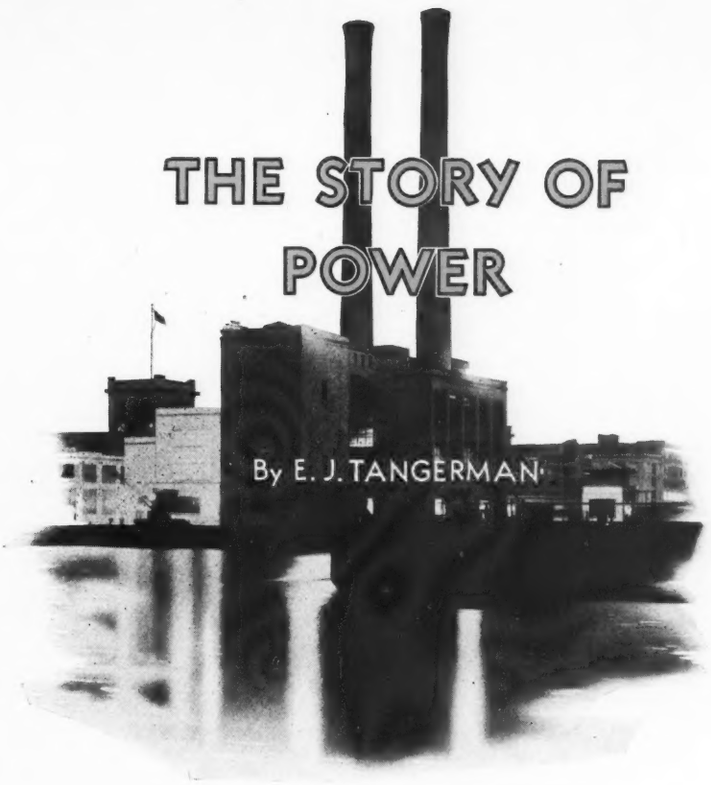
From the historical section the reader may gather inspiration and a new appreciation of sturdy pioneers. From the broad survey of present practice he may increase his practical knowledge and test his own performance. And when finally he turns to read what some dare think of the unknown future, he may agree or disagree, as is every man's right, but he cannot fail to throw new light on the old question "Where am I going, and why?"

Finally we may be pardoned a brief word about *Power,* the publication. This magazine was founded with a single aim—practical help to the men who design, build and operate plants to supply power to industry. *Power* has never deviated from that aim. Today, more than ever, it holds to this purpose of its founders. This anniversary number, we trust, is another example of that practical service.

Philip Swain

Editor

THE STORY OF POWER



By E. J. TANGERMAN

COUNTLESS thousands of years ago, man *was* power. Though he was weaker than most other animals, he survived them because he learned to apply simple principles of conversion to what power he had available. At his utmost, he could develop but a tenth of a horsepower continuously, a horsepower for a few seconds. But the bow brought him speed, the lever power.

In those days, he was his own isolated plant. His single boiler burned fuel at temperatures below a hundred degrees. Draft, fuel-handling, ash-handling, low-water and low-fuel alarms, stoker, automatic lubrication, central control board—he had them all. Energy produced by his boiler drove several hundred queer half-engine, half-battery, prime movers. Many of these engines (the muscles) had each a half-million cylinders in parallel. Plant efficiency, fuel to work, exceeded that of a modern central station.

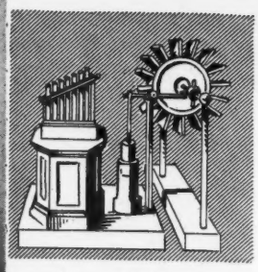
But with all its efficiency and marvelous control, the human body was pitifully weak. The control board—the brain—forever demanded more than one prime mover could provide. Soon this resulted in coupling prime movers in tandem or compound—the prime movers being called slaves. Possibly the greatest central station of this type was the 400-hp., 4,116-slave unit possessed by Caecilius, freeman of Rome in the days of Caesar Augustus. Not to be sneezed at were the 5-banks-of-oars Roman barges, in which several hundred slaves pulled together.

Even this did not satisfy man for long—he wanted greater concentrations of power. So he pressed the ox, the ass, the horse, even the dog, the camel, the elephant and the dromedary, into service. This was somewhat better—a man develops 30 to 50 ft. lb. per sec., the ass raises it to 110, the ox to 300, the horse to 400 or 500, the camel to 800 or 900.

In those days the treadmill was no reducing fad. Men first walked them, then dogs, horses and oxen. Claudius Caudex took the Roman army across the Straits of Messina to Sicily in oxen-propelled, paddle-wheel boats. With its companion transmission, the winch (known in Babylonia 4,000 years ago), the treadmill works even now on land for hoisting water.

But long before Rome, man had learned the power of wind and water. Egyptians, 4,000 years before Christ, drifted down the Nile with the current and sailed up again with prevailing winds. In other lands, the wind was not so obliging. It blew from any quarter it chose, sometimes it didn't blow at all. But when it did blow, it offered real possibilities, for even a 30-mile wind a hundred feet high by half a mile wide can produce the power of 50,000 horses. So we find the sail coming to shore, giving engineers of 2,000 years ago something to worry about—to keep the sails in the wind. A genius finally mounted an early mill atop a revolving post upon a tripod. Early ones weren't fastened down, so if the wind blew a lusty blow, over went the mill.

Europe claims the windmill, but apparently the East has a prior claim. Hero of Alexandria, grandfather of the steam turbine, describes the use of windpower in 150 B.C.; there are stories (possibly forgeries) of windmills in Wales in 340 A.D., in Canterbury in 669, in Bohemia *until* 718 (when the waterwheel replaced them), in Mercia in 833, in Persia in 915 and 943, in Newburg in 1105. The more likely story is that Crusaders brought them back to Europe from the East.



Hero, 150 B.C.

Post Mill, 1100 A.D. Vane Mill, 1200 Sweep Cap, 1400 Meikle, 1750 Farm Unit, 1900 Madaras, 1933 Savenius, 1933

Dean Herbert is said to have built a mill to grind his corn as early as 1191. The abbot didn't like it, forbade it, and had it destroyed. But prohibition has always been the greatest urge to ingenuity, so windmills soon appeared all over England.

Early mills were turned by manpower to face the wind. Later millers substituted mules as the turning device. Then the millstones had to be housed to keep the wind outside, and the mules soon had to turn house and all. Someone solved this by making only the cap rotatable on a track, turning it by means of a long arm, or rack and winch. Then in 1750, along came a budding genius named Meikle who set a smaller fan at right angles to the main one, its axle driving a pinion on a circular rack inside the cap, or geared to the wheels of a heavy car which it could drive around the mill, to turn the cap.

But windmills took over one big job under the constant Dutch winds, thus earning their place in history. At the peak of their use in pumping the North Sea from the *polders* and the *Zuider Zee,* there were 10,000 of them hard at it.

We still use windmills in America, mostly on farms and out West for raising water. Many supply light as well. A few old windmills move in high society out on Long Island, N. Y. The base of another stands at Truro Park near Newport, R. I., built by Gov. Benedict Arnold, grandfather of the Revolutionary traitor, shortly after 1665.

Usually the mills were four-armed. The 100-ft. tower mill at Whitby, England had five, that at Lewes had six, modern tower mills carry many small vanes, a proposed one has but one. Sometimes tip-to-tip diameter was a hundred feet with sails and hub weighing more than a ton. Sometimes peripheral speed got to 3,000 f.p.m.—making the mill a formidable opponent for even a better knight than Don Quixote. If you don't believe it, try riding into a train at 35 m.p.h.

Now, as economy of power production becomes vital, the windmill bids fair to come back. Great Britain's Royal Agricultural Society held a windmill contest in 1903. Seventeen makers submitted 22 mills with efficiencies around 23 per cent. Savenius rotors, S-shaped units revolving horizontally, do still better. Flettner developed a rotor for his rotorship, Madaras is experimenting with the idea in Jersey, German inventors project huge windpower machines reaching high into the air to catch higher, less-variable winds. But we still use other sources for our power. Wind's big job today is to fill legislative buildings and to propel the yachts of the rich.

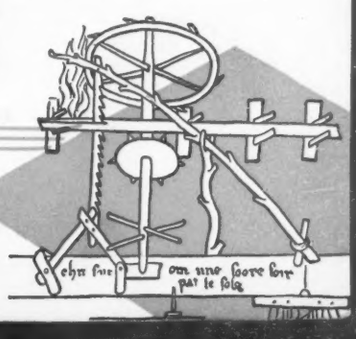
WATER POWER

APPARENTLY, man's stomach has always been his prime mover in any great development, for the first waterwheels, like the first windmills, were designed to grind meal and to lift water for irrigation. Egyptian engineers lifted water from the Nile to dampen the rich but parched land beside it. Whether they originated the idea or simply stole and "improved" it is in doubt. First mention of the waterwheel is about 85 B.C., by Antipater.

Strabo, the geographer, told of Mithradates, King of Pontus, and the hydraulic machine he built at Cabira about the time Pompey defeated him in 65 B.C. Pliny says in his Natural History (75 A.D.) "In the greater part of Italy is used a roughened pestle, or wheels turned by water, and sometimes they employ also for the purpose the mill." Outside these references, there is no conclusive evidence that the water mill was common in Rome until the fourth century. In 398, the rulers issued an edict to protect the water supply used for driving mills in the city. By 485, Zeno had to forbid private use of mills, and Theodoric, 50 years later, resorted to waterwheels on the Tiber to supply the city with water when it was besieged. It worked famously, so other Romans used the idea. But critics pointed out that much water slipped by without working. So engineers chose narrower points in streams, even narrowed streams to fit. Still water escaped under the barge. The only answer was to remove the barge and anchor the waterwheel to dry land.

These were all flat-bladed wheels. Meanwhile, the Chinese had developed the Nora, a horizontal-shaft wheel with triangular paddles of bamboo and reed, and hollow sections of bamboo at the end of each paddle to carry a little of the water to a flume above. Vitruvius, the Roman, described a similar wheel driving a grain mill in 16 B.C., and mentioned that its horizontal axle drove the vertical mill shaft through gearing—earliest known reference to a power transmission.

All these early wheels used water velocity only—the energy inherent in its weight went to waste. This made the undershot wheel (as we call it now) of little value on sluggish streams. Some Roman engineer finally reversed the chain-and-pot pump idea, putting buckets on the undershot wheel instead of paddles, and sending water over the top instead of under. This used water's weight, but lost its velocity. A partial



By the thirteenth century, they were trying water-driven sawmills

answer was to use wooden troughs instead of jars, but about that time the Middle Ages threw a pall of darkness over everything.

All early waterwheels lifted water or drove mills. Ausonius mentioned a water-driven saw to cut marble, but it wasn't until the twelfth century that the waterwheel became a working tool of general use. One charter of 1154 speaks of the mill used for crushing bark; other references of the same time speak of it for driving crude textile machines; the thirteenth century brought the mill for sawing wood.

Blast was the real job for the "new-fangled" overshot wheels. By 1600 they were being put in throughout Europe. Largest and most powerful for many a long year was the wheel at Cyfarftha Iron Works, in South Wales, England. Built in 1800, it was 50 ft. in diameter, 6 ft. wide, with 156 buckets, and turned at 2½ r.p.m.

But in some places, fall was so high that one overshot wheel couldn't be built big enough to take it, and it seemed a crime to let the additional head go to waste. The result was tandem set-ups similar to those at Macclesfield, which had wheels connected by idler gears so that they turned in the same direction, or that at Aberdare, South Wales, which had the lower wheel toothed to the upper, thus turning in the opposite direction. With both of these, efficiencies were fair.

But the world had still to learn what waterwheels were all about. The man who was to tell was the near-genius, John Smeaton. One day he explained to the Royal Society that if the head of water is the same, the amount of energy produced by two wheels depends upon the quantity of water each receives, and, conversely, if they receive the same amount of water, energy depends upon the head. This set engineers again on the right trail toward the elusive higher efficiency. The result was the breast wheel, a sort of combination of the overshot and undershot wheel, produced by making the water strike the blades just below wheel center and holding it against them for the remaining quarter turn by close-fitting sluices. Belper Cotton Mills had one 40 ft. wide, 12½ ft. in diameter, with an efficiency of 75 per cent.

But the world was crying for more and still more power—meaning water turbines. Leonardo da Vinci, painter and mechanical jack-of-all-trades, had shown the way. This extraordinary genius in oils was also a specialist in chains, rope and belt drives, universal joints, spiral and bevel gearing, and centrifugal pumps. He also found time to worry about the old flat-bladed waterwheel which produced mostly splashing and noise. Actually, what he designed was a water turbine with curved vanes convergent toward the center, which caught and extracted power from the water instead of splashing it all over the surrounding landscape. His design wasn't very good, but it was much better than anything older.

Seventy-five years went by while men battled over this idea. Finally Besson, in 1568, produced a cone-shaped pit wheel which extracted energy from both water's velocity and its weight.

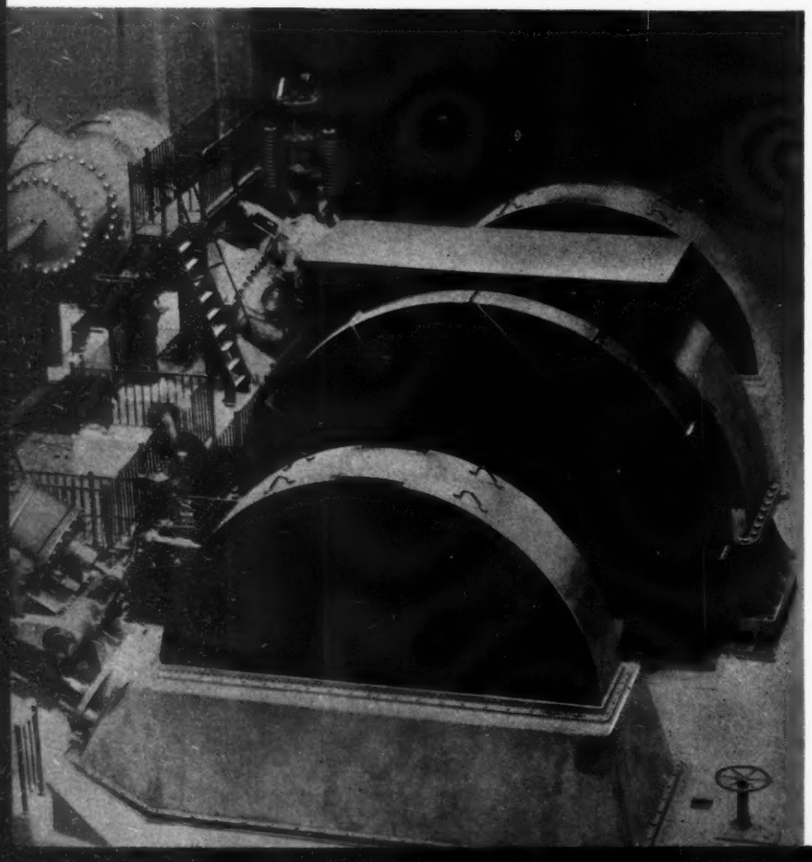
Another fifty years drifted by until Dr. Barker had his idea. He simply took Hero's "aeolipile" and substituted two radial L-shaped arms from a central water-filled pipe. Naturally, as water spurted out of the holes at the pipe ends, the arms spun from the reaction. Today we simply call it a lawn sprinkler and forget it.

And so the science of hydraulics began to have growing pains. Desagouliers, Euler, Bernouilli and De la Cour worked with this whirligig. De la Cour suggested that if a pipe from an elevated reservoir had its bottom end bent upward like a J, and a Dr. Barker's mill be put on the lower end, a water motor would result.

Meanwhile, a French youngster had begun to do some really practical work. In 1823, as a lad of 21, Benoit Fourneyron had begun playing with the old horizontal wheel. Four years later he had produced a remarkable turbine with a water-tight casing. He introduced water at the wheel center, and caused it to run out to the periphery—the first wheel in which all the water had to do work.

Further experiments followed, until in 1834 Fourneyron got the contract to build a 7-hp. wheel to drive a furnace-blast compressor at M. Carron's iron works at Francho-Comte. Head was only 9 in., but the wheel did the job so far beyond M. Carron's expectations that he ordered a 50-hp. (huge for those days) machine to replace two old waterwheels which had delivered 30 together. According to report, head was only 4¼ ft., but the wheel worked so well that Fourneyron was soon kept busy supplying wheels.

The New World saw its first wheel in 1601, America its first twenty years later. Many of the New England townsites were at narrow spots on rivers where water ran swiftest or where there was an ap-



One of two highest-power impulse wheels, 62,400-hp. unit at Big Creek 2A. Effective head 2,418 ft.

preciable fall. One of the earliest mills was built by Israel Stoughton in 1634 at the Lower Falls of the Neponset River, between Milton and Dorchester, Mass., where head was about 8 ft. It was first a grist mill, then a sawmill, then a powder mill—and is now owned by Walter Baker Chocolate Mills. One of the most famous American overshot wheels was the 60-ft. wheel of Burden Iron Works, Troy, N. Y., 20 ft. wide, producing 278 hp. at 85%.

It was no real surprise when Uriah A. Boyden and James B. Francis, smart Yankees, went Fourneyron one better on water turbines, for they brought true design to wheels. Samuel Howd had patented an "inward-flow" wheel in 1838, reversing the action of the Fourneyron turbine. This seems to have been the origin of the American type. After other small designs, Francis, in 1849, designed an inward-flow turbine of the same general type as the Howd, but along more scientific lines and of better construction.

Two of these wheels built by Lowell Machine Shop for Boott Cotton Mills showed 80 per cent efficiency. Other inward-flow wheels soon followed, including the Swain (1855), American (1859), Leffel (1860), and Hercules (1876). With these wheels going in universally, the water turbine had largely superseded the waterwheel by 1870. The waterwheel now is used only where built locally in isolated places.

Boyden also deserved much credit for development. In 1844 he had designed a wheel for the Appleton Co. works in Lowell, Mass. It rated 79 per cent efficiency—two he built for Appleton two years later were claimed to be 88 per cent efficient. It is certain the figure was over 80.

In 1882, in Appleton, Wis., a tiny hydro-electric plant lit 250 lamps. It was the first of the 16,000,000 hp. installed today.

Back in 1849 an Ohio carpenter named Pelton had gone to "Californy" in the gold rush. In 1884, 35 years older and wiser, he saw real gold, not in the sands below the streams, but in the streams themselves. Adopting a waterwheel commonly used by miners, he set it up on the Chollarshaft, in the Sierra-Nevada mountains, to be run by waste surface water under a head of 1,600 ft. His wheel used a small jet of water at very high velocity directed against the buckets, which look like a clamshell opened flat. The center ridge split the stream into two halves, which drove against the bucket bottom and reversed as they came up the other side, delivering 80 per cent of energy to the bucket. Onto this wheel Pelton hooked a 130-hp. dynamo designed by Charles T. Brush. The "juice" went a mile to Nevada Stamp Mill.

His wheel is still indispensable for high heads. Lake Fully, Switzerland, now has the world's high-

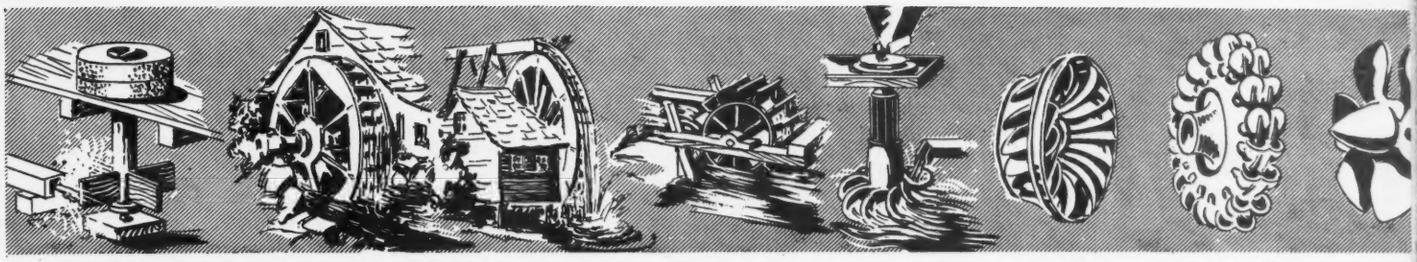
Highest head francis wheels in America (850 ft.) are in Oak Grove plant (left). At Tiger Creek (above) are two 36,000-hp. units driven by impulse wheels under 1,190-ft. head

est-head station (5,412 ft.) in operation, creating a nozzle pressure of 2,350 lb. per sq.in. This will soon be exceeded by Dixence, in the same country, with a head of 5,715 ft. and five 50,000-hp. units.

At Niagara Falls, N. Y., head was only 151 ft. (total possible 220 ft.), but there was lots of water that had long been going to waste (if the view and the facilities for tightrope walkers and oblivious honeymooners be excepted). By 1861 a canal was built to divert some water from the rapids above the falls, but not until well after the Civil War, in 1877, were several small wheels installed. These supplied a little power through shafting. 1891, however, brought a different story. The Famous Power House No. 1 was begun at Niagara. It was to house ten 5,000-hp. turbines driving two-phase a.c. generators. Its success upon completion in 1897 was so great that it stimulated development on both sides of the river.

Until fifteen years ago, Francis-type wheels were used almost exclusively for low heads. They were fairly satisfactory, but there was need for a wheel less affected by changes in head, operating at higher speeds and easier on the pocketbook. Forrest Nagler and Lewis F. Moody, in the United States, and Kaplan, in Europe, solved the problem by developing propeller-type wheels. Those developed in this country are essentially fixed-blade designs, although some have runner-blade pitch adjustable manually. Kaplan's design has blade pitch automatically adjusted by the governor. Some 3,500,000 hp. of propeller-type turbines have been installed—about half in

Chinese Nora, ? B.C.



Indian, 100 A.D. Undershot, 300 (?) Overshot, 700 (?) Breast, 1780 Flutter, Basic Turbine Francis, 1849 Pelton, 1884 Propeller,

Europe, the rest in Canada and the United States.

And so we come to 1934 with 16,000,000 hp. of hydro-electric units installed in this country. Hydro units, in 1933, produced over 40 per cent of the power generated in central stations.

It is estimated that there are 440,000,000 hp. of hydro-power available at ordinary flow, for 50 per cent of the time, in the world. This would permit installation of about 1,000,000,000 hp. of water-wheels. About 55,000,000 hp. have been installed.

STEAM

MISTS of unrecorded history veil the beginnings of man's knowledge of steam. Two thousand years and more ago, Hero of Alexandria described in his "Pneumatica" (150 B.C.) steam-using devices of men of his time and earlier. Most of the units have been credited to Ctesibus, the great inventor.

Hero clearly described three methods for using steam as a power source: raising water by elasticity, elevating a weight by its expansive power and producing rotary motion by reaction on the atmosphere. The latter was exemplified by "Hero's Engine" or the "Whirling Aeolipile," a hollow sphere supported over a cauldron or boiler by two trunnions, one of them hollow and connecting sphere and boiler. Steam from two right-angled projecting jet pipes spun the sphere when the cauldron was heated. Or, explained Hero, simply take a cauldron full of water, put a jet pipe on it, and heat it. The jet will turn paddlewheels or blow horns.

Hero also described an engine used to open and close temple doors. A fire was kindled on a hollow altar connected by a short pipe to a sphere of water. As the air within the altar was heated it expanded, forcing water out of the sphere through a siphon into a bucket suspended from ropes on hoisting drums. As the bucket filled with water, it grew heavy enough to rotate the drums, thus opening the doors "mysteriously."

A thousand years passed, while the works of Hero crumbled into dust. Only once, outside the temples, was steam used, and then to win an argument. Anthemius, architect of Justinian, and his neighbor, Zeno the orator, had had a dispute which Zeno won easily. But Anthemius, not to be bested, took several cauldrons and ran flexible tubes from them up to his neighbor's rafters, where he narrowed the tops. Thus, when he built a fire under the cauldrons, the steam made organ pipes of the tubes, producing a one-house earthquake.

Through the darkness of the Middle Ages, a few faithful ones remembered steam, and passed some of the facts along. Gerbert, professor at Rheims in 1125, built an organ blown by air from a vessel in which it was compressed "by heated water." Cardan invented the "smoke-jack" in 1550. Matthesius in 1571 described a simple steam engine and explained the "tremendous results which may follow the volcanic action of a small quantity of confined vapor." Jacob Besson described steam generation at Orleans in 1569, and the Italian, Agostino Ramelli, added to the discussion in 1588.

The great Leonardo Da Vinci, engineer and painter extraordinary, described a steam gun, the "Architonnerre," ascribed to Archimedes, which fired a ball by the action of steam generated suddenly by throwing water on charcoal. Giovanni Battista della Porta, Neapolitan mathematician and philosopher, inventor of the magic lantern, described in 1601 a simple pump which showed the separation of boiler and prime mover called new by inventors 150 years later. Salomon de Caus, French engineer and architect, discussed steam in a treatise in 1615, as did Giovanni Branca of Loretto in 1629. De Caus even built a fountain operated by steam pressure.

So began a comedy of errors. De Caus was among the first of a long series of half inventors who each contributed one useful idea and many useless ones to the knowledge of steam. Branca's idea was the grandfather of the impulse turbine. He took one of Hero's steam generators and aimed its jet tube at a paddle wheel. The paddle wheel turned the pinion, the pinion a gear. It carried on its shaft a drum with short pegs which alternately lifted and released long rods carrying drug stamps.

David Ramseye got the first English patent Jan. 21, 1630, on steam engines (then called "fire engines"). Blasco de Garay, Spanish navy officer under Charles V, is claimed to have tried to move a ship by means of steam-driven paddle wheels as early as 1543, which, if true, is the first attempt to use steam for practical work. Dr. John Wilkins, eccentric scholar and Bishop of Chester, suggested in 1648 a steam-driven flying machine, a bell chime, yarn reel and cradle rocker. He does say seriously, however, that the aeolipile was used for blast in melting glass or metal. Kircher, German Jesuit, brought up Branca's idea again in 1656. Ercworn in 1672, described common use of aeolipiles for blast.

Hero's Aeolipile, as the Greeks redesigned it

Florence Rivault, gentleman-of-the-bedchamber to Henry IV, had discovered as early as 1605 that water confined in a bombshell and heated would explode the shell, no matter how thick were its walls. Edward Somerset, second Marquis of Worcester, took up the idea in 1628. He filled a cannon with water, plugged the touchhole and the end, and built a fire under it. Within 24 hours it burst with a bang. With that bang came the Marquis' idea—the "water-commanding" engine which he first built in 1628, at Raglan Castle (the wall niches are still there). He connected two water-filled globes by pipe with a stopcock. The first was the aeolipile, the second like de Caus' steam fountain. When the first was heated, the steam forced water from the second up through a jet tube "like a constant fountain stream 40 ft. high." He built a second at Vauxhall in 1647.

Jean Hautefeuille, learned French abbé, proposed the use of alcohol in an engine in 1678, "in such a manner that the liquid should evaporate and be condensed, and turn about without being wasted"—surface condensation and the closed operating cycle. Sir Samuel Morland, even in 1683, had a very accurate knowledge of the volume and pressure of saturated steam.

Huyghens had as one assistant a young French Protestant, Dionysius Papin. When Louis XIV revoked the Edict of Nantes, life in France became unbearable for Protestants, so Papin moved to England and helped Robert Boyle invent the air pump and air gun. By 1680, busily engaged in studying pressures, Papin thought of a "steam digester for extracting marrowy, nourishing juices from bones by enclosing them in a boiler under heavy pressure." In building it he made one invention that no steam boiler, or cooker either, has even yet learned to do without—the safety valve.

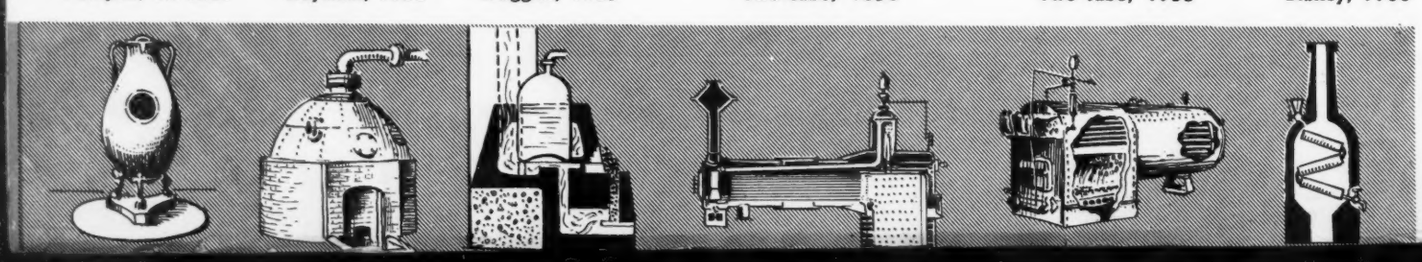
Ten years later he introduced another idea. In a cylindrical jar he put a piston and rod, with a cord from the top of the rod passed through overhead pulley to a weight. Then he blew steam below the piston until it was lifted to the top of the jar. When the steam was shut off and cold water sprayed around the outside, the steam suddenly condensed. Promptly the piston dropped to fill the vacuum thus created, and lifted the weight from the table. Here was the first steam engine with a piston.

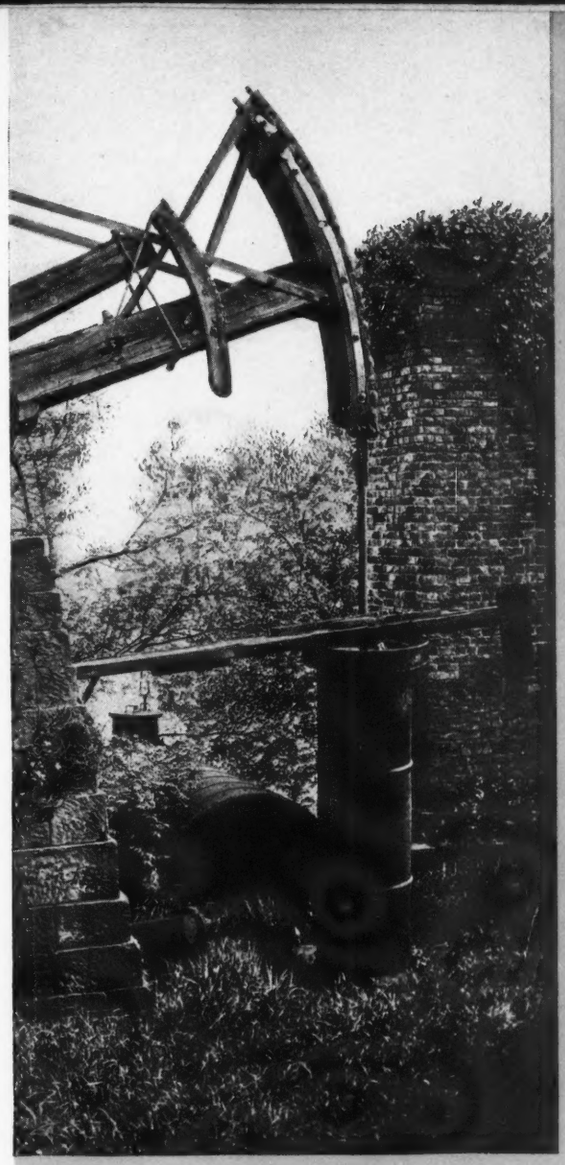
Now Big Business was interested. British coal was then dug from open pits which were not only flooded from ground water, but also caught rain. Man-powered pumps, then horse-treadmill pumps, both became inadequate as mines grew deeper. Why not set this peculiar vapor steam to lifting water instead of weight?

Capt. Thomas Savery decided to try it. By 1698 he had a patent. The next year he exhibited a model before the Royal Society consisting of two copper receivers alternately connected by a three-way hand-operated valve with a boiler and a source of water supply. When the water in one receiver had been driven out by steam, cold water was poured over its outside, creating a vacuum and causing it to fill again while the water in the other receiver was being forced out. A number of mine pumps were built on this principle.

The great difficulty in Savery's engine was the limited pressure the boiler and vessel could bear. One he built for a mine owner at Kingston would pump a few pounds of water at four gulps a minute. For this mechanical marvel Savery charged all of $250. Everything was rosy until the operator forgot to treat the temperamental engine very, very carefully, when it proceeded to blow itself all over the adjacent landscape. Desaguliers later fixed that difficulty by applying a Papin safety valve to the

A crumbling Newcomen engine, reminder of 1725, these "water forkers" were common in





the days when steam power was young. By collieries and were standard for 60 or 70 years

boiler and substituting condensation by a jet within the vessel for Savery's surface condensation.

But it was time for another practical man. About eight years after Savery's engine became pulverized history, Thomas Newcomen, blacksmith of Dartmouth, communicated a great idea to his assistant, John Cawley, a glazier. Forthwith they went to work and a year later produced the "atmospheric engine," the first which actually looked and acted as a steam engine should. Proportions were mainly by luck. Steam from a kettle-shaped "haycock" boiler passed into a cylinder and raised a piston, assisted by a counterweight on the other end of the walking beam to which the piston rod was connected. The steam valve was then shut and the steam condensed by cold-water outside the cylinder. The atmosphere promptly pushed the piston down to fill the vacuum. This machine actually would pump water at seven or eight strokes a minute.

By 1711 this engine was being generally introduced into mines for pumping. Whether its action was originally automatic or dependent upon hand-valve operation, we are not quite certain. The story is that a boy, Humphrey Potter, was a valve-operator in 1713. Upon his diligence depended engine speed. But Humphrey Potter was lazy, so he cast about for some one or something to do his work for him. It seemed to him that every time he opened or closed a certain valve the walking beam was in a certain position. So Humphrey hooked up strings from the water and steam valve levers to the walking beam. Sure enough the beam didn't mind the extra work, so Humphrey delegated his job and fell asleep.

Suddenly the mine owner noticed his pumping engine working as it never had before, and 15 or 16 strokes a minute instead of eight or ten. Humphrey lost his job. Henry Beighton, five years later, simplified the idea with the "plug-tree," which actuated the valves by tappets. The valve gear was born.

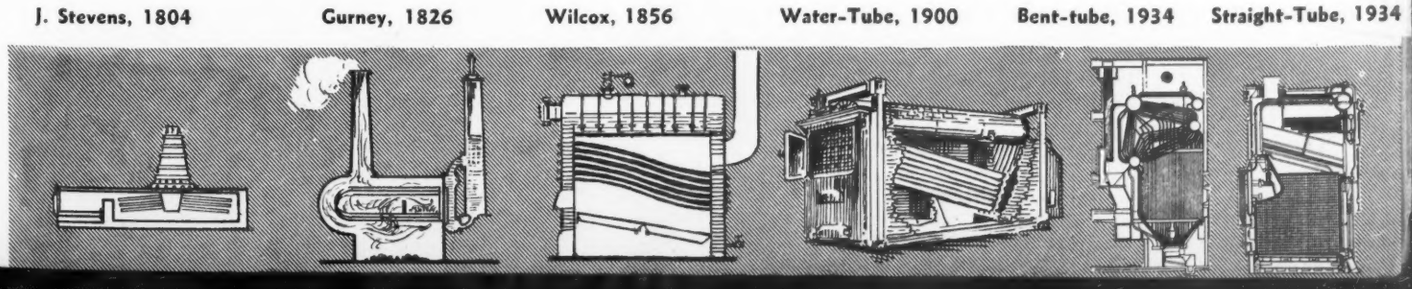
Now for an accident. These early Newcomen engines were extremely slow and wasteful of steam, until one day the sealing water leaked from above the piston into the cylinder. Some astute watcher noticed the engine running with a speed and surety it had never had before. Steam was being condensed much more rapidly. So was born the jet condenser.

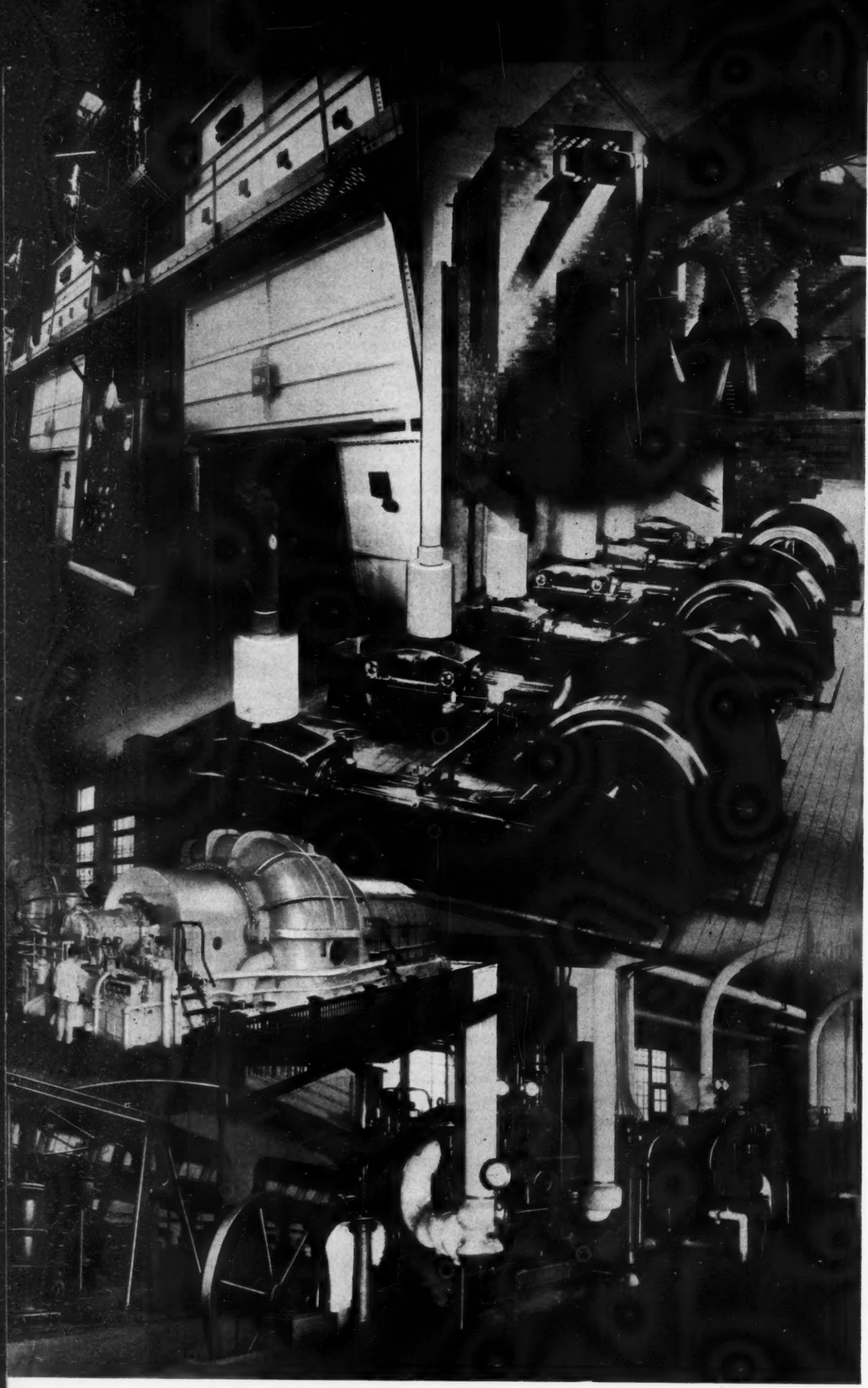
After hearing of Savery's first engine Papin had developed an improved form in 1705, a non-condensing, single-action steam pump with steam and pump cylinders in one. It also had a curious device for keeping steam dry during expansion. This was a mass of heated metal in the separating diaphragm which might properly be called the first superheater. Papin also suggested about this time a boiler with an internal firebox, the earliest record of such construction.

Now thrifty operators began thinking of that familiar bugaboo, fuel-saving. Dr. John Allen, in 1730, explained that almost half the heat was lost because of the short time of contact between gases and boiler heating surface. He suggested an internal furnace with a smoke flue winding through the water in the form of a worm in a still, and a pair of bellows to force the sluggish gases through the flue. Here was probably the the first suggested use of forced draft.

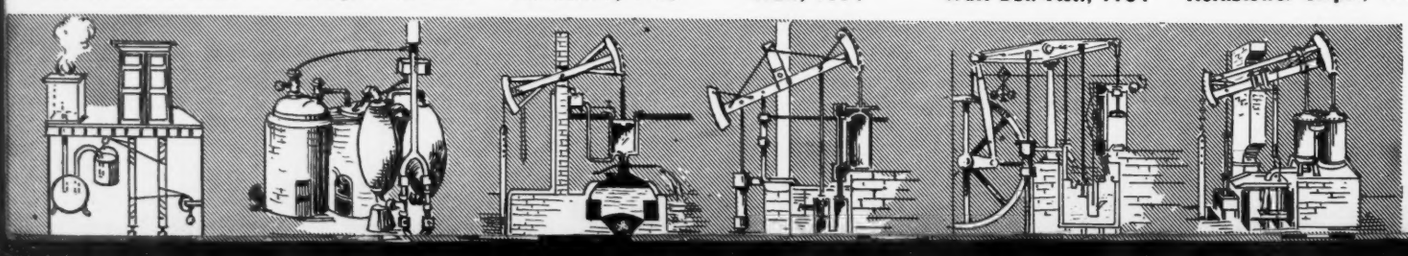
But it was not until 1769 that the original Newcomen engine was greatly improved. John Smeaton did it, then built and installed a number of large engines. He also insulated the piston, developed a feed-water heater, and introduced Newcomen's engine throughout Europe, even building one to drain the Czar's drydock. Four years before this Gene Blakey had taken out a patent covering an improvement on Savery's engine, which included a novel

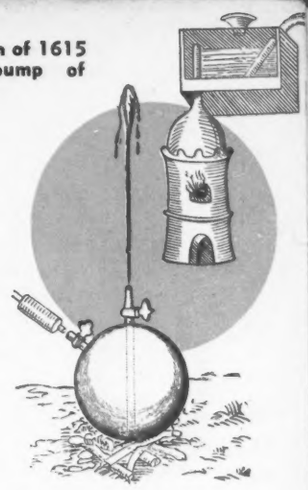
J. Stevens, 1804 **Gurney, 1826** **Wilcox, 1856** **Water-Tube, 1900** **Bent-tube, 1934** **Straight-Tube, 1934**





Temple Door, 150 B.C. Savery, 1702 A.D. Newcomen, 1705 Watt, 1774 Watt Dbl.-Act., 1784 Hornblower Cmpd., 1781





DeCaus' fountain of 1615 and Porta's pump of 1601

form of steam generator—probably the first attempt at a water-tube boiler.

Perhaps we had better mention James Watt, for we have the steam engine invented. Born at Greenock, Scotland, Jan. 19, 1736, Watt was the son of a local "jack-of-all-trades"—carpenter, undertaker, town treasurer, bailie (a little more than a sheriff), ship chandler, merchant and contractor. James, a sickly lad, was rather closely tied to his mother's apron strings, being capable only of whittling, fishing, studying wild flowers and tinkering with mathematical instruments.

When he was about 17, his father (whose many abilities failed to keep his family in shoes) sent James off to Glasgow to become apprentice to a "mathematical instrument maker." But Glasgow's one instrument maker spent most of his time making and selling fishing tackle, interesting, but hardly the sort of thing young Watt wanted to learn. He caught a convenient cold and went back home, then to London. Those were the days of the Guilds, and Watt faced a 7-year apprenticeship. The story is he got around it by bribing an instrument maker with 20 guineas to teach him for a year, all this being without knowledge and consent of the Guild.

His bootleg training completed and with another of his perpetual colds, Watt went back to Glasgow to set up shop, but this didn't work either. The Corporation of Hammerman of the City of Glasgow —Watt's Guild—would permit no man to set up shop who was not an indentured Glasgow apprentice or the son of a burgess. They voted him out, straight into the hands of Dr. Dick, professor of natural philosophy at the University of Glasgow. Dick made him instrument maker within the University's cloistered walls.

Watt's little first-floor shop soon became the gathering place for those serious souls who wanted to discuss mechanical problems. Among regular visitors was Dr. John Robison, then a student of about Watt's own age, who suggested even so early as 1759 the rash idea that steam might one day propel carriages. Watt was impressed. He talked the idea over with Dr. Joseph Black, who was studying the properties of steam. 1762 found Watt building a simple cylinder fitted with stopcock and piston. In the midst of this, the 2x6-in. Newcomen engine of the University had one of its frequent sick spells. Watt had to fix it, and thereby started a new train of thought.

1764 found him ready to use a real engine. He got the Newcomen model from the University and built a new boiler for it. He found one amazing thing—steam would heat six times its own weight of water to the boiling point. Right there he pitched down his pencil and hunted up Dr. Black, who tipped him off to latent heat.

Suddenly Watt saw that steam was far too valuable to use wastefully. He first tried to economize in the boiler with a wooden shell, then more flues, insulated the steam pipes. But he soon found that the trouble was in the engine, largely in heat dissipated by the cylinder and by the alternate cooling and heating. First he tried a cylinder of wood soaked in oil, then baked. It was much more economical, but wouldn't stand up. Comparing the amount of steam used in each stroke with the quantity that would just fill the cylinder, he found that at least three-fourths was wasted, and that he used four times as much injection water as should suffice. It appeared obvious that the thing to do was to keep the cylinder "always as hot as the steam that entered it." But how to do it was the problem.

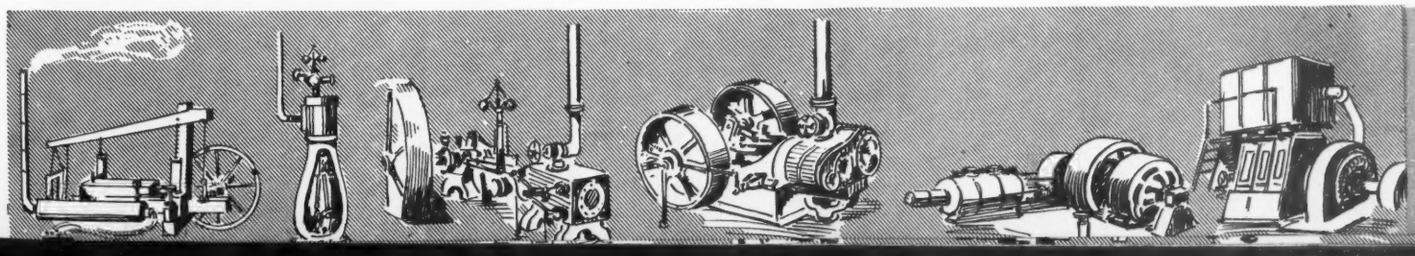
Now Watt was a great walker. Says Watt, "I had gone to take a walk on a fine Sabbath afternoon (spring, 1765). I had entered the green by the gate at the foot of Charlotte St. and had passed the old washing house. I was thinking upon the engine at that time and had gone as far as the herd's house when the idea came into my head that if steam was an elastic body it would rush into a vacuum, and if a communication were made between the cylinder and exhausted vessel it would rush into it, and might there be condensed without cooling the cylinder. I then saw that I must get rid of the condensed steam and injection water if I used a jet, as in Newcomen's engine. Two ways occurred to me. First, the water might be run off by a descending pipe, if an outlet could be got at a depth of 35 or 36 ft., and any air might be extracted by a small pump. The second was to make the pump large enough to extract both water and air. . . I had not walked further than the golf house when the whole thing was arranged in my mind."

In other words, Watt had suddenly fallen upon the idea of the separate condenser. But the idea was slow to translate itself into an actuality. They say that Dr. Robison strode into Watt's little work room, to find him staring gloomily at a little tin cistern on his knee. Perhaps this cistern started the story about his mother's tea kettle (also told about Savery and Worcester).

Finally, the engine began to show promise. He found that water lubrication was causing cooling, so he substituted oil and tallow. Air cooled the cylinder behind the piston at each stroke. He closed the cylinder top and inserted a stuffing box. He added a steam jacket and allowed boiler pressure to pass from jacket to the space above the piston.

Watt now gave up everything else. With one assistant, John Gardiner, he built, within two months, an engine with a cylinder 5 or 6 in. in diameter and 2-ft. stroke. It worked better than his first, but now he was broke. Again it was Dr. Black who helped him out, this time by introducing him to Dr. Roe-

Evans Non-Cond., 1800 Vertical, 1850 Corliss, 1857 Horiz Compound, 1900 Uniflow, 1934 Vertical, 1934

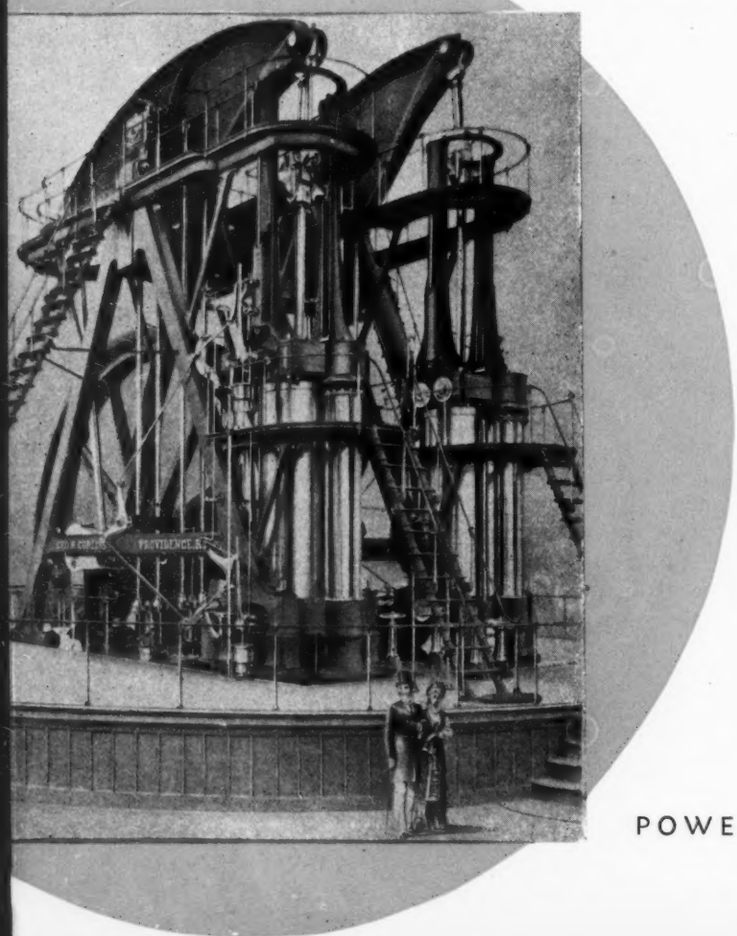


buck of the Carron Works, which then owned a heavy forge shop and the inevitable flooded coal mines. Dr. Roebuck commissioned Watt to build a practical engine to unwater his mine, the Carron Works to produce the cylinder casting, Watt to construct the piston and other parts. Watt's part of the job turned out fairly well, but the cylinder had the interior appearance of a testing ground for snakes. Watt began a long siege of reboring and refitting that was to last almost four years. But even after two years of this, Roebuck's hopes were still so high that he agreed to pay off £1,000 of Watt's debts in return for two-thirds interest.

Finally, in 1769, the engine was finished. It was set up with high hopes but low capital. It worked, but the badly bored cylinder was still causing trouble. Watt tried oil rags, cork, finally an old felt hat, but the leaks continued. Water kept rising in the mine, the flood bringing with it the usual debt collectors. Dr. Roebuck went bankrupt.

But down at Soho, north of Birmingham, Matthew Boulton manufactured cheap clocks, silverware, chains, telescopes, and polished precious stones. His power he got from two old water wheels, except in summer when the stream dried up and he had to use horses. Boulton, hearing of Newcomen's engine, had tried to turn his mill "by fire." Eventually he had even discussed it with our countryman, Benjamin Franklin (who then was supposed to know everything about everything). By 1766 they were discussing in their letters the applicability of steam.

The "Centennial" Corliss most awesome of steam engines



Meanwhile Watt, on a journey through London in 1767, had carefully inspected Boulton's establishment. The following year, he again visited the works and met Boulton, who discussed Watt's plans, then definitely decided not to continue his own experiments, although he had actually commenced a pumping engine. When Roebuck failed, Boulton was holding his note for £1,200, just £200 more than Roebuck had advanced Watt. Boulton, normally a good business man, mentioned to Roebuck's creditors that he might trade his note for Roebuck's share in Watt's invention. To troubled executives trying to settle an estate that was non-existent, this was manna from heaven.

So in 1773 the firm of Boulton & Watt began business in Soho. As do most firms, they built their first engine for advertising purposes, christened it "Old Bess," and set it to pumping water for a waterwheel.

But "Old Bess" interested John Wilkinson, iron works owner of Broseley. He ordered one. "In the name of God, fall to and do your best," wrote Boulton to Watt, a pleading probably more fervent because of Boulton's vanished £1,200. But Watt was already hard at it. In 1776, Watt began his first commercial engine—the engine that was really to begin the Industrial Revolution. Piston and cylinder were fitted to a thin shilling (1/40 inch) by hammering and filing. Finished the same year, it really presaged tremendous development of steam.

Watt differed from most of his predecessors in that he had more than one idea in a lifetime. Previous engines simply poured in steam until the piston reached the cylinder top, then poured the steam into condenser, still at full boiler pressure. But Watt noticed that the steam sometimes kept on working after he shut off the supply. Amazed, he began to test and found that he got three-fifths as much power from each stroke, even when he cut off steam supply at quarter stroke—the idea for cutoff.

Soon came the second order, this time for an engine to pump 15,000 gal. of ale an hour. Two London distillers bought a third, a Wales mine owner a fourth. By 1780 Boulton and Watt had sold 40 "grasshoppers." Now each partner supplied an idea. Boulton introduced a horizontal U-shaped flue from the firebox running down the boiler and back to a chimney at the front. Here was the "Waggon" boiler, which made the Haycock obsolete. Even then the shell was still so frail that two safety valves were required—one to keep the boiler from *exploding* under pressure, the other letting in air to keep it from *imploding* if the fire went out.

Watt contributed the crank and connected rod in 1780. It had been used for at least 2,000 years, but never had been patented. But Dick Cartwright, one of his pattern makers, imbibed too many glasses of ale with his friends one Saturday night. He boasted of the circular motion Watt was getting from a piston rod. To somebody's "Oh yeah?" he

replied by chalking a picture on the bar. That would be the night in which James Pickard, Birmingham button manufacturer, was hanging about the tavern waiting to pick up what he could about Watt's new plan. He took a good look at the sketch, then went to London and patented it himself.

Watt, sturdy Scot, wouldn't pay a cent of royalty to a man he knew was a thief. Boulton and Watt were already paying a royalty to Matthew Wasborough, who had patented the flywheel. He also bought the patent for its combination with the crank as patented by Pickard and Steed.

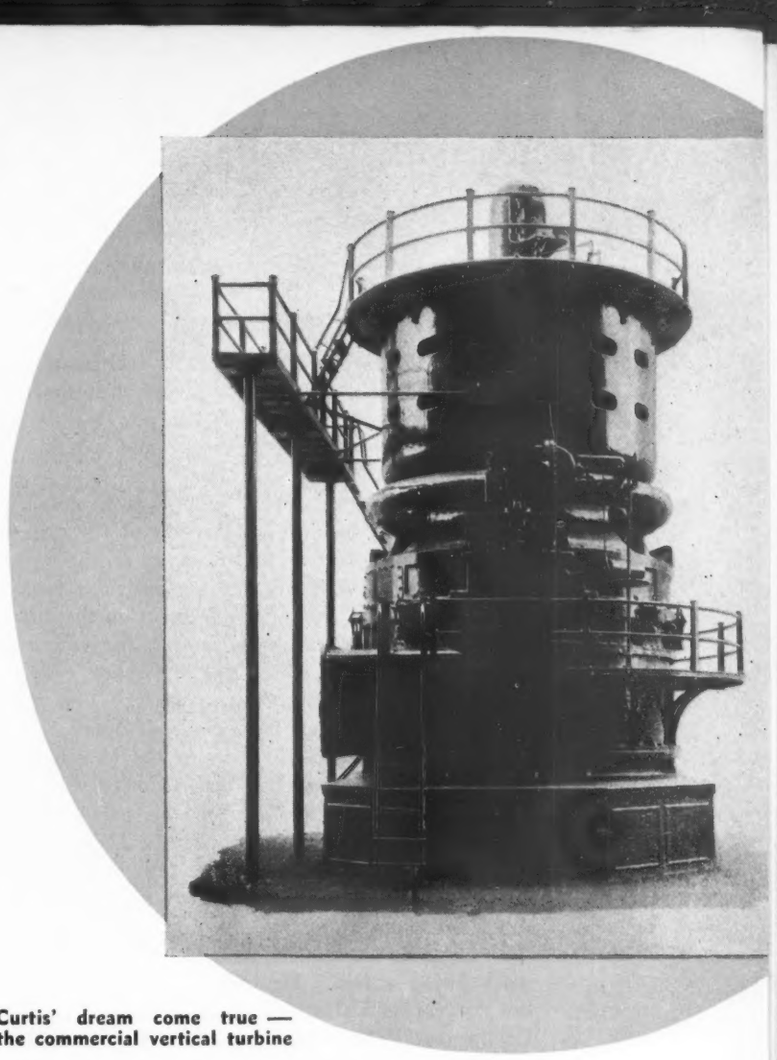
Boulton grew ever more insistent, finally writing Watt June 21, 1781, "The people in London, Manchester and Birmingham are *steam-mill mad*. I don't mean to hurry you, but think that in the course of a month or two we should determine to take out a patent for certain methods of producing rotary motion of the fire engine—remembering that we have four months in which to describe the particulars of the invention." Watt's reply was to develop five different subterfuges to avoid the crank, among them the familiar "sun and planet" motion.

Watt by now was receiving only £330 a year, but had spent over £40,000 of Boulton's money without any great return. But Watt helped out by inventing the term "horsepower" to show how many horsepower his engine would replace. Skeptical mine owners insisted that Boulton and Watt take the risk, taking their payments from savings. Therefore Watt had to develop an automatic counter. The firm's collector read these regularly, and with a record of coal burned, figured the cost of doing work. Gradually little driblets from here and there began to repay Boulton, and the Watt engine came into its own because it paid purchasers $2 in savings for every $1 it paid its builders. Watt also developed the throttle valve, the double-acting engine, a mercury steam gage and a glass water column, as well as the familiar steam-engine indicator.

Watt always argued that his engine was too rough and undependable for use in milling; primary uses were in pumping or blowing bellows. Boulton finally took the bull by the horns—he accepted a contract for a corn mill engine, guaranteeing to grind four times more corn per bushel of coal than any other engine. To meet the contract Watt had to design a governor-controlled engine. The result was the now familiar fly-ball governor.

Watt had once introduced a bill in Parliament to make high pressures unlawful, and had rejected Jonathan Hornblower's idea of compounding, first offered in 1781. But Hornblower received a patent on it. This credits him both with the compound engine and the separate surface condenser. Watt objected that his own steam valve cutoff gave all the advantage of compounding without its defects and defeated Hornblower in a patent suit—but not the idea.

Arthur Woolf began building compound engines



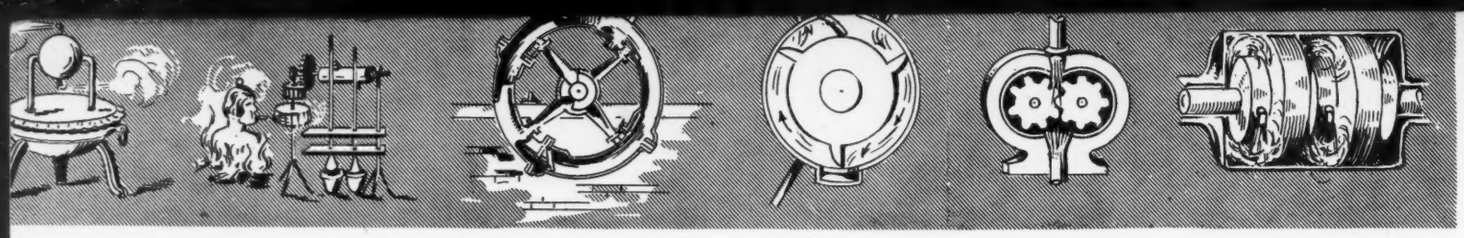
Curtis' dream come true — the commercial vertical turbine

in 1804, four years after the Watt patent expired. By 1805 he had several operating. Ten years later I. & J. Lean, mine superintendents, made comparative tests of Watt's and Woolf's engines. Woolf's showed uniformly better, but, of course, were newer. They delivered power more smoothly, and each cylinder held more nearly to a constant temperature than was possible with a single-expansion engine. But the high-pressure single-expansion "Cornish Pumping Engine" of Richard Trevethick, cheaper to build and operate, almost made men forget the compound engine in turn. Oliver Evans meanwhile was introducing the same type unit in America, and was experimenting with high pressures.

In 1827 Jacob Perkins patented an engine with two cylinders with a bore ratio of 8 to 1. He proposed compound operation, using 1,400 lb. steam pressure, and a cutoff of one-eighth stroke in the small cylinder. Neither boilers nor cylinders were available to withstand such a pressure.

Hornblower had imported America's first steam engine in 1753. Deane, Evans and Fitch had worked with them. George Henry Corliss came along, born in Easton, N. Y., June 2, 1817. About 1846 he designed his first machine, for sewing shoes. To Providence, R. I., he took it, to Fairbanks & Bancroft to build the model. After that arose the difficulty. Corliss had no capital. Discouraged, he started home.

But Fairbanks & Bancroft, impressed with the



Hero—150 B.C. Branca—1600 A.D. Watt—1769 Cartwright—1797 Murdoch—1799 Gillman—1837

young Corliss, offered him a job as draftsman. Corliss took it, liked it, and soon was enthusiastically inventing again. This time it was power—the new-old idea of automatic valve release and variable cut-off governors.

The first engine Corliss built was a slide-valve type with a D-valve at each corner of the cylinder, two intakes at the top, two exhausts at the bottom. The feature was not only the changed valve position, but the automatic release arrangement on the intakes. This introduced some complications, for valves had to be operated by a connecting wristplate oscillated by an eccentric from the main shaft. This valve-releasing gear also had to include dashpots

The firm saw enough merit in the idea to make him, not yet 30, a partner. When Corliss was 31, in February, 1848, he had justified his partners' faith by producing a 260-hp. engine with a 22-in. cylinder and 72-in. stroke, a radically new design. It *worked,* it *saved* steam, it *was easier* to govern, it *would hold* speed much more constant.

With these advantages, Corliss was soon hard at work filling orders. He built two engines the following year, and also took out a basic patent. Then Corliss met Watt's bugaboo—patent trouble. Frederick Sickels had patented a fixed-release arrangement seven years before. His could be varied by hand, but wasn't tied into the governor. Thurston-Green, of Providence, builders of the Sickels engine, entered suit, claiming automatic release. Corliss countersued, claiming the idea of tying in governor and valve release. It took Corliss 15 years and a hundred thousand dollars to win vindication.

All engines, practically, had used William Murdoch's slide valves. Even after Corliss had built some half-dozen engines, his outstanding trouble was still valves. Finally, one of his mechanics suggested a rotary type. Now Corliss didn't accept ideas that weren't his own—so he alibied by saying that the rotary valve was merely his slide valve "rolled up," but straightway began to use it.

Let us take a look at Corliss in those days, in his shop 635 x 85 ft. The day's work has started. The end door opens. Down the shop walks an imposing man, tall, well-dressed, smooth shaven with shaggy eyebrows—George H. Corliss. His high silk hat, the hat he always wore, tilts back on his head. His men catch this from the corners of their eyes, and those who can do so slip out of sight behind machines or columns. For the world of Corliss is out of gear when that hat is out of plumb.

Corliss was in some ways a good business man, in others a bad one. He advertised that his engine would operate more smoothly than anything previously built. He also advertised that his engines would save high percentages of coal for any equal amount of power delivered. And here canny Yankees picked him up—if his engine would do it, why not back it himself? Corliss was forced to install engine after engine on a pay-out-of-savings basis.

But his engines never failed him, no matter how extravagant the bet. The owners of a flour mill ordered a 180-hp. engine, agreeing to pay him the value of fuel saved in five years. Corliss built the engine for $7,000; the purchasers paid $19,734.22. He sold an engine to drive rail-mill machinery, guaranteeing delivery of one-third more power on two tons of coal than the previous engine had turned out on five. Excess coal was to cost Corliss a dollar a pound. The engine came through.

Corliss' masterpiece was the "Centennial" engine, built in 1876 for the Philadelphia Exposition. It was a vertical, two-cylinder walking-beam type which eventually developed 2,500 hp., designed originally to supply the 1,400 hp. estimated necessary for Machinery Hall. It weighed 607 tons and required thirty-five freight cars to carry it from Providence to Philadelphia. The 30-ft. flywheel alone weighed 56 tons, each walking beam 11. Its 25-ft. connecting rods were forged from 9,600 old horseshoes. And Corliss, on threat of taking the engine out, forced the Exposition management to shut down all machinery on Sunday.

After the Exposition, the engine was dismantled and brought back to Providence. There it stayed for four years. One day, Mr. Pullman came to see it. Corliss had suddenly instructed Frank G. Tallman to junk the bad ones of a batch of castings. Tallman chalked every faulty casting "BAD," and moved them into a line along the track. When Corliss brought Old Man Pullman through, hell popped, but Pullman bought the engine. It served at 2,500 hp. building sleeping cars until 1910, when a lowly turbine replaced it.

Incidentally, the huge 30-ft. flywheel had spur-gear teeth cut in its rim, so perfect that foreign engineers tested them with penknives to be certain that they weren't wooden inserts. These were cut by a secret process—laid out nights and Sundays—but they ran silently. At an engine speed of 36 r.p.m., they had a pitch line speed of about 3,500 ft. per min.—and we consider 2,000 f.p.m. fast today!

We are a nation of speed maniacs. Even so early as 1862, Chas. T. Porter and John F. Allen exhibited a 150-r.p.m. engine at the London International Exhibition, shocking staid Britishers. This brought in the long series of automatic cutoff engines which eliminated the leisurely Corliss dash-pot arrangement. Other names which will be familiar are: John E. Sweet, E. D. Leavitt, Benjamin F. Avery, Pardon Armington, Frank Ball, A. L. Ide, B. W. Payne, all developers of sweet-running "high-speed" engines.

Peter Brotherhood in 1872 began development of an unusual high-speed engine; P. W. Willans produced one the next year. Dr. A. C. Kirk suggested in 1874 that if double expansion was better than single, why not try triple, even quadruple expansion? But John Ericcson, designer of the *Monitor* and blaster of all ideas not his own, was so vitriolic about it that these engines didn't begin to come into use for six or seven years, then largely at sea where space is always at a premium. Pressures grew to 200 lb. per sq. in., coal consumption dropped to 1½ lb. per hp.-hr. One recent achievement is two 3,750-kw. triple-expansion engines operating at 1,500 lb. pressure and 797 deg. F.

But even as engines grew to steam-driven Goliaths, a tiny David, the steam turbine, smote them down. The turbine was smaller, cheaper to build, higher in speed, and can be built in large sizes. However, engines have steadily undergone refinements, until now we have a variety of horizontal and vertical types, many using the uniflow principle in which steam is not required to change its path, traveling in a straight line into the cylinder and out again, decreasing cylinder condensation.

Turbines

Hero had shown 150 years before Christ the basic elements of the reaction turbine. Branca showed the impulse principle 1750 years later. Paradoxically, James Watt, father of the practical steam engine, always had a lingering suspicion that rotating motion was better than reciprocating. In 1769, when his engine was enjoying its first successs, he tried to use steam to push a piston continuously around inside a tire-shaped cylinder, but valves and driving mechanism were too complicated.

His great trouble was excessive friction, but his 1782 redesign was very nearly as bad. It wouldn't work, so Watt dropped it. Cook (1787), Bramah (1789), Symington (1790) and Kempel (1794) tried it too, but without success.

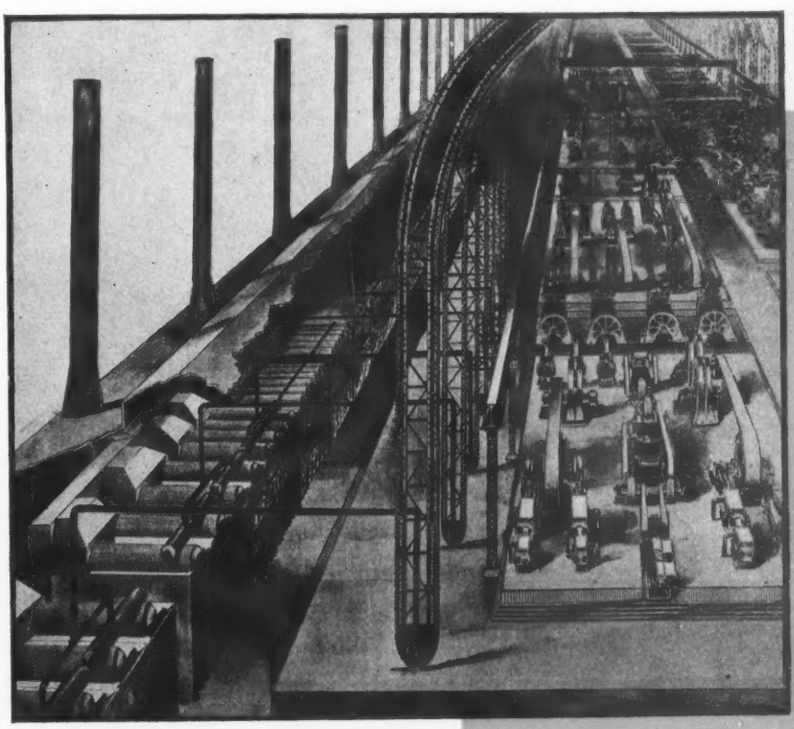
Finally, Rev. Edmund Cartwright, father of the textile industry, picked it up. His 1797 (the year in which he also patented a condensing engine) design was similar to Watt's, but with two steam inlets and three pistons. It was to work on "distiller's wash" instead of water, and to act as combination still and engine, but it did neither. Hornblower tried one the same year, but couldn't keep the packing tight.

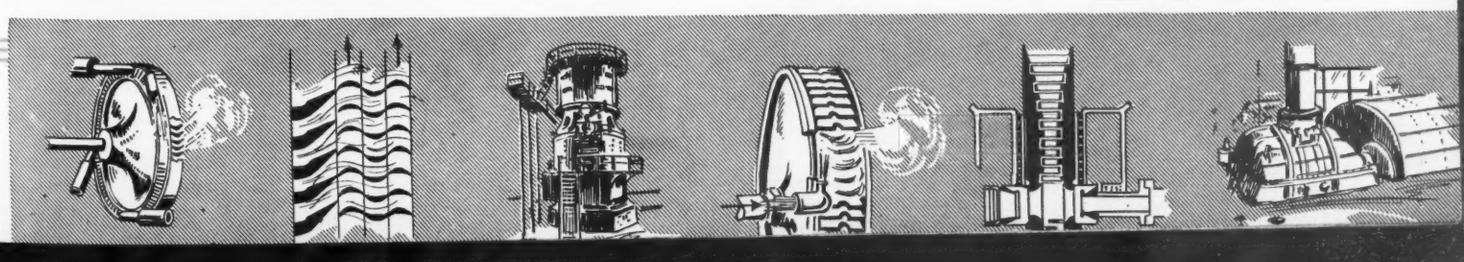
William Murdoch really came close to getting the idea in 1799. He built a machine with two gear wheels in mesh, the forerunner of one common rotary pump. Steam was to be blown against the wheels at their point of contact and was to exhaust at the opposite side. But Murdoch had failed to reckon with the crude mechanical equipment and cruder mechanics available to build it.

Gillman, in 1837, planned to drive a rotary engine by the velocity of steam, rather than by its "push." On a single shaft he placed several wheels separated by diaphragms. Steam entered the first wheel, expanding outward. It then passed through the diaphragm to the center of the next wheel, and so on. But Murdoch's trouble also stopped Gillman. The basic idea was available all the time in the work of such men as Sadi Carnot, French physicist. One great difficulty was the steam nozzle, which ever since Branca's design had been made converging like a water nozzle. Inventors forgot that steam, unlike water, expands and thus requires a diverging nozzle for efficient operation with a large pressure drop. Heath chanced upon this idea in 1838, after engineers before him had bungled it for 200 years. Bresson (1852), Heel (1852), Harthan (1858) and Perrigault bungled it after him, though Harthan did suggest better ways to use steam for rotary motion.

Finally, Carl Gustav Patrick De Laval, son of an Army captain and trained engineer with a doctor of philosophy degree by 1872, played with the idea of centrifugal machinery and hit upon the centrifugal cream separator. As he could not persuade his employer, Kloster Iron Works, to take up the invention, he returned to Stockholm in 1877, where he finally produced a commercially successful machine. The smaller sizes worked very well by hand, but the larger one certainly required something else. The steam engine was too slow, and De Laval decided that the almost 2,000-year old idea of Hero was better than anything that had been developed between times. By 1882 he had built a machine based upon Branca's

Power for the World's Fair at Chicago in 1893





idea of blowing steam against the vanes of a wheel. He was a good engineer and his design was logical, but efficiency was very low. He had made the mistake of using a converging nozzle, and it took him six years to find out that Heath had devised exactly the nozzle he needed 50 years before and that Reynolds had worked out the theory in 1885. So De Laval redesigned his wheel with blades of carefully calculated curvature and brought the mouth of his diverging nozzle close up to its job. Suddenly, he had high efficiency and a turbine capable of turning itself from 10,000 to 30,000 r.p.m. and of delivering a horsepower from a 4-in. rotor.

Of course, De Laval now met the same difficulty that all his predecessors had—he was forced to convince all the skeptics in Christendom. Even the U. S. Patent Office (in 1889) said the machine would not work and refused, at first, to grant him a patent. De Laval was also a pioneer in the use of high-pressure steam. By March 9, 1897, he began commercial use of high-pressure steam in his own works.

The next turbine was a direct return to Hero. Steam was permitted to expand only in the moving blades of the rotor, pushing the rotor around just as a man stepping from a boat drives it away from shore. This new design was developed by the fourth son of the third Earl of Rosse, Charles A. Parsons. When he was 29, in 1883, he came out with a brand-new turbine that soon turned out to be one of history's greatest inventions. By 1889 he was building wonderful marine turbines in his own factory. He had already patented a multi-stage turbine by 1884, really a large number of bladed disks strung along a central shaft in a steam-tight casing. Between these wheels, projecting in from the casing, were stationary blades to guide the steam along the turbine.

The next man to tackle the turbine problem was Charles A. Curtis, electrical manufacturer of Brooklyn, N. Y. In 1895 he began to try to combine, in one turbine, the impulse and reaction principles, the result to be used to drive ocean liners. It was an expensive idea. He and Crocker, his partner, soon spent $60,000 in experiments. Finally, however, the General Electric Company bought Curtis' idea and spent millions in experimentation to make it a commercial success.

Mention should certainly be made of Auguste C. E. Rateau, who anticipated Curtis on some design elements and was a tremendous force in the development of turbo-electric machinery.

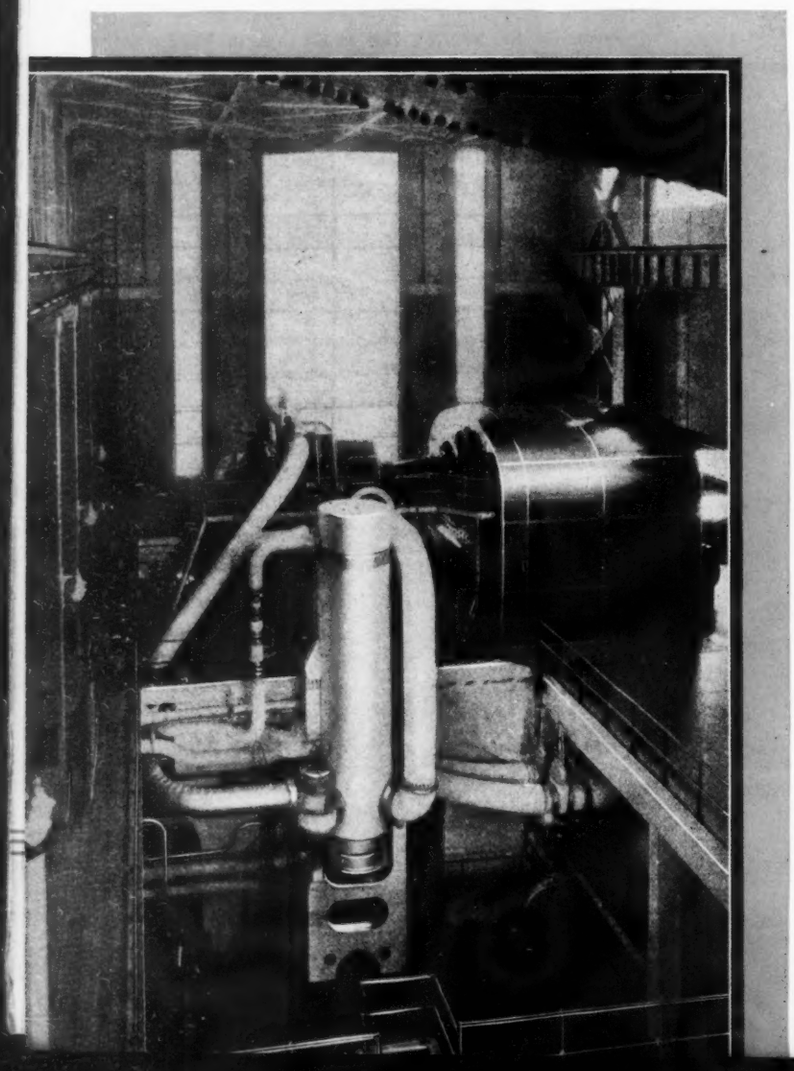
Expansion of the use of turbines still continues. Curtis turbines are said to produce 15 million horsepower on land alone. Today we have turbines of 200,000 hp. Such a machine does the work of four million slaves.

General

It goes almost without saying that boiler development has kept pace with that of prime movers. This tremendous advance can probably best be shown by the strip of sketches on pages 288 and 289. Another development worthy of mention is central heating. Birdsill Holly tried it first in 1877 at Lockport, N. Y. This was followed by several district heating projects, notably New York Steam Corp., which supplied heat to its first customer, a printing establishment just before Pearl St. station was finished in 1882. Today about 10,000 individual customers are served in the United States from central heating plants which deliver about 20 billion pounds of steam annually.

There have always been those engineers, and still are, who realize that water isn't the ideal fluid for engine operation. Its highest boiling point temperature, which determines theoretical efficiency, is limited to 706 deg. and requires very high pressures. But water was so common, so accepted, that after Abbé Hautefeuille, it wasn't until 1912 that W. L. R. Emmet even dared to suggest another fluid. He suggested mercury, which boils at 677 deg. F. Obviously mercury can be heated to a much higher temperature than water, before the heat begins to show up as very high pressure. Emmet experimented for five years and in 1917 evolved a system that looked so good it was only another six years before Dutch Point Station, Hartford, Conn., made a costly experimental installation. The unit was a success; since then several others have been installed.

Other fluids than mercury have been tried or considered. While, to date, none has been as successful, the future may tell a diffierent story.

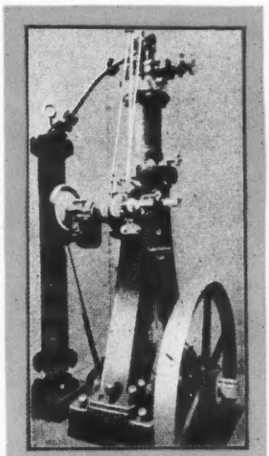


Largest high-pressure turbine, 110,000-kw., 1,400-lb. steeple-compound unit in Ford's River Rouge plant

OIL AND GAS ENGINES

CHRISTIAN HUYGHENS, Dutch physicist, suggested as long ago as 1680 that gunpowder might be made to do work if exploded in a closed vessel with a movable top. Either he didn't think of continuous work, or he faced the problem of a small boy with a carbide cannon—after every shot it must be recharged. Others after him, notably Papin and Abbe Hautefeuille, faced it, and were beaten by it. Barber tried first to produce power from an inflammable gas in 1791. Motive power produced by explosion was proposed the same year by Robert Street. Three years later he patented the first real gas engine.

Lebon suggested in 1801 that the air-gas mixture might be compressed before ignition. Sir George Cayley gave the whole story away as early as 1809, when he wrote: "The French have recently shown a great power produced by igniting inflammable powders in closed vessels, and several years ago an engine was made to work in this country in a similar manner by inflammation of spirit of tar (benzene) *.....Probably a much cheaper engine of this sort might be produced by gas-light apparatus, and by firing the inflammable air generated with a new portion of common air under a piston.*"



Proof of compression ignition, Rudolf Diesel's first experimental engine

But the idea still languished. Samuel Brown built the first gas engine that did real work in 1823, and a double-acting engine in 1830. Next came W. L. Wright, 1833 and William Barnett, 1838, the latter inventor of a flame ignition and usable compression system. A. V. Newton and Drake (an American) simultaneously invented the first hot-metal igniters in 1855. Barsanti and Matteucci, two years later, proposed the first free-piston engine and introduced a rough spark ignition.

Now we come to the man who first used Cayley's suggestion, Gene Joseph Etienne Lenoir, the Luxembourgian. In 1860 he produced a hydrocarbon motor burning benzene and supposed to develop 3 hp. It was a non-compressing, horizontal, double-acting, reciprocating unit, with crank and flywheel, working on a crude two-stroke cycle. This engine had an annoying habit of stopping, and even when it did run developed a meager 4 per cent thermal efficiency.

But it did stimulate development. Schmidt, the next year, and Alphonse Beau de Rochas, in 1862, worked out the four-stroke cycle. Julius Hock built a practical petroleum engine (non-compression type) in Vienna in 1870. Two years later, the Yankee, George Brayton, patented an engine burning a gas-air mixture at constant pressure—an important step. Burning gasoline, it developed 6 per cent efficiency.

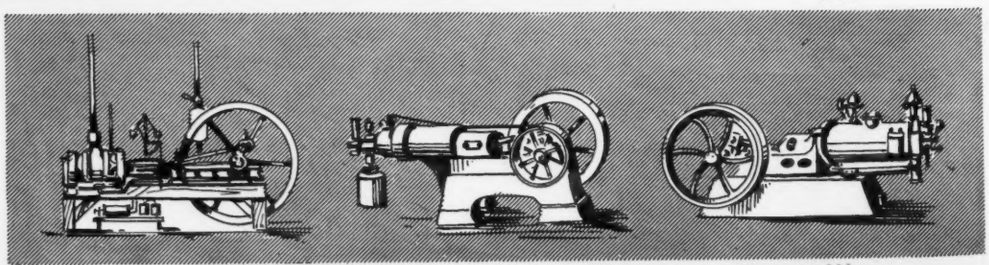
Now came the German, Nicholas A. Otto, who, with A. Langen, produced a free-piston engine, a refinement of the Barsanti and Matteucci design, which had a fuel consumption only a third that of the Lenoir engine. Otto, seeing virtue in De Rochas' ideas, dropped the free-piston idea to develop the famous Otto Silent Engine, a single-cylinder horizontal unit with sliding-plate admission valve and poppet exhaust valve, actually compressing the charge before firing. This, the forerunner of today's automobile engine, was first shown at the Paris Exposition of 1872. By 1878 it looked as though Otto's suction producer-fed gas engine would become the standard stationary unit, but Spiel was already pointing the way with an oil engine without an independent vaporizing apparatus, which was giving him an efficiency of 0.81 lb. per b.hp.-hr.

With this impetus, the gasoline-driven automobile began to be developed, paving the way for our something like 29 million automotive vehicles, which develop, assuming a conservative 25 hp. per engine, one billion horsepower—almost fifteen times as much as all other prime movers put together.

Still there lingered in some men's minds the persistent hope that the poor thermal efficiency of prime movers might be improved by Brayton's controlled combustion. The great step was in the mind of Rudolf Diesel, who began studying a new type of internal combustion engine in 1879. He planned to compress no charge or mixture, only the air to support combustion. Fuel was to be introduced into the "red-hot" air at the end of compression, the heat of compression being enough to cause immediate ignition. Constant pressure was to be maintained throughout combustion, and gases were to expand even after introduction of fuel had ceased. Three times too much air was to be provided to insure complete combustion. The fuel was to be pulverized coal with a rotary valve or oil with a spray valve. Diesel was a good engineer, so good that he worked out almost every detail of his engine before he poured a casting.

By 1893 Diesel's first engine was ready for test. He started the transmission drive and opened the fuel valve. The engine immediately blew itself all over the landscape, almost killing Herr Diesel in the process. But he was happy, for here at last was proof that his compression-ignition idea was sound.

Two years earlier Priestman Brothers, of Hull, had made a heavy-oil engine after a French patent, which developed 5 hp. and had a fuel efficiency of



Lenoir, 1860 Clerk, 1865 Otto, 1872

0.84 per b.hp.-hr. But even before this, Charles Ackroyd Stuart had patented an engine in England in which only the air charge was compressed, the fuel being introduced by a pump and gasified and ignited by a hot vaporizer. Apparently Ackroyd Stuart anticipated Diesel on pure-air compression and later solid injection of fuel, but used a hot bulb.

Before Diesel had well recovered from the explosion he had a new machine designed, water-jacketed and with an improved air and fuel injection pump. Maschinenfabrik Augsberg-Nürnberg, A. G. (now internationally known as MAN) and Krupp, agreed to finance him. The successful engine, produced in the MAN shop, was tested Feb. 17, 1897. It kept Dr. Diesel's original air suction and adiabatic compression to high pressures and kept fuel-oil injection at almost constant pressure by an air blast. Thermal efficiency was 27 per cent and fuel consumption about 0.5 per b.hp.-hr.

Three separate developments are responsible for the American so-called diesel of today, the first from Dr. Diesel's original idea; the second from a low-compression, four-stroke cycle engine, first built here in 1893 and gradually developed to the present design through increases in compression and improvements in combustion system; and the third originating in the two-stroke cycle, hot-bulb engine invented by Charles Weiss and first built by Mietz & Weiss in 1895. This engine was really a combination of the Day two-stroke cycle, crankcase-compression, gasoline engine, and the oil vaporizer of Priestman and Ackroyd, using the two-stroke cycle invented by Dugald Clerk in 1880.

The first diesel to be put into regular power service was not a German unit, but one built in St. Louis, Mo., in 1898, of 60 hp., and after Diesel's design. The credit is largely due to one man, Adolphus Busch, king of American brewers, who spent a part of each year on vacation in Germany. During his visits in the Nineties, Baron von Krupp continually discussed Dr. Diesel's experiments with the crude-oil engine. Mr. Busch, realizing that this engine might satisfy the need for cheap power in small American factories, immediately began negotiations and finally purchased American rights for $250,000, based on Dr. Diesel's American patent of 1895. Supposed to run until 1912, this patent actually expired in 1906.

Busch formed the Diesel Motor Co. of America in 1896, first trying an engine after the Krupp design. This was unsatisfactory, however, so the new company evolved one started on air on the two-cycle principle. It was an 11x20-in. unit, running at 200 r.p.m., and developing 20 hp. Fuel consumption was high, because of poor atomization, and the engine worked poorly. But design modifications ended the difficulty, and commercial construction began.

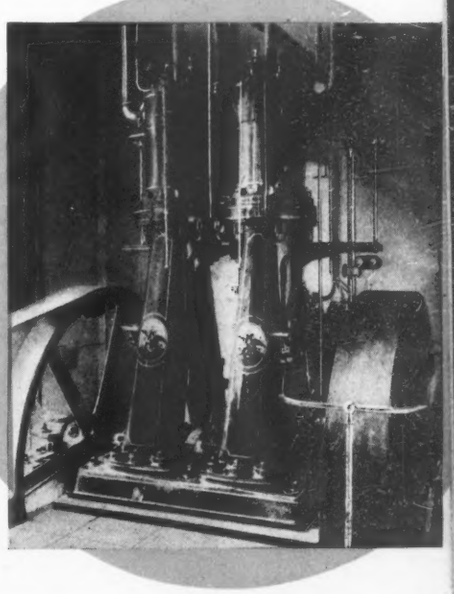
When Diesel's American patents were supposed to be running out in 1912, Busch opened negotiations with Sulzer Brothers, in Switzerland, who had done as much or more than any other company to popularize the diesel, and soon began building four and two-stroke cycle engines after Sulzer designs. Meanwhile, in Germany, under supervision of Dr. Lauster, experimentation had steadily been carried on, and by the end of 1900 some 500 hp. of diesel engines had been sold. Most of these were crosshead units. The first trunk-piston engine was built in 1901, being a single-cylinder unit of 70 hp.

But, as with the compound steam engine, it was naval use which really brought the diesel into the limelight. In 1903 the German Navy started its first diesel. Two years later the French Navy ordered four for submarines. About 1904, the Nürnburg plant of MAN secretly developed a two-cycle diesel for the German Navy, and in 1908 began construction of double-acting two-cycle units.

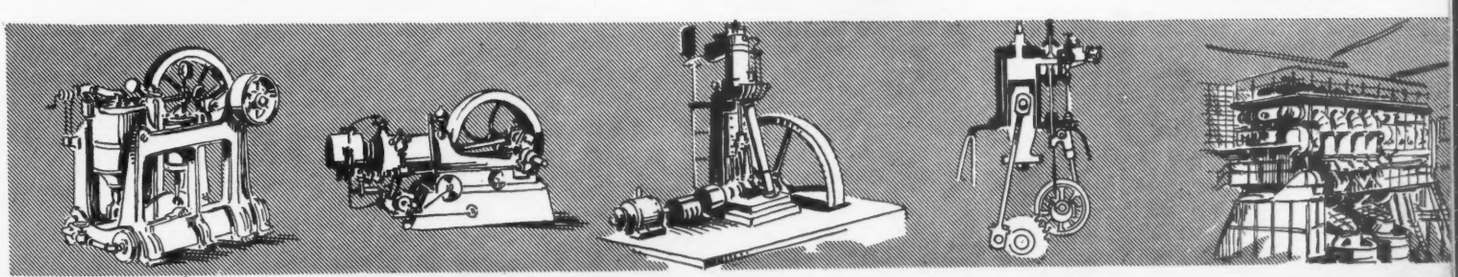
Dr. Diesel never lived to see real success. After a United States lecture tour in 1912-1913, he went back to England in September of the latter year. As the Harwich-Antwerp mail steamer *Dresden* chugged its way across the English channel, Herr Diesel disappeared. But the engine he invented has lived on.

Rudolf Pavlikowsky, who was formerly Dr. Diesel's chief draftsman, has recently built three diesels burning powdered coal—the original Diesel idea—an interesting return to early ideas.

The number of diesel engines in use has mounted steadily, and their refinements have cut down fuel consumption and increased reliability. Back in 1906 the total production of oil engines was less than 100,000 hp., with diesels only a small part of the total. In 1928 the total production of American oil engines had passed the 5,000,000-hp. mark, while that of strictly diesel engines was somewhere around 2,250,000 hp. Through subsequent years, this has been increased to about twice this amount.



World's first commercial diesel, a 60-hp. unit built at St. Louis, Mo.



Brayton, 1872 **Ackroyd-Stuart, 1886** **Diesel, 1897** **First Amer., 1898** **Copenhagen, 1933**

ELECTRICITY

AMBER, when rubbed, attracts small bits of chaff. Thales of Militus, Greek mathematician and philosopher, first wrote of this in 585 B.C. Aristotle explained about the same time that lodestone (magnetite ore) "has a soul, since it moves iron." Since the city of Magnesia produced the best ones, Euripedes, in 400 B.C., first called the pieces "magnets."

Susruta, Hindu physician of Thales' time, described early surgical use of the magnet; Plato talked of its power to attract iron rings and to impart a lesser power to the rings. Theophrastus (372-286 B.C.) decided that amber and lodestone belonged together because both attracted other materials. Seneca the Roman (100 A.D.) talked of lightning, thunder and St. Elmo's Fire; Pliny and Aristotle spoke of the torpedo, strange fish which shocked those who touched it. Eustathius even talked of a freedman of Tiberias cured of the gout by this means and of the sparks which jumped from his clothes when he changed them. Plutarch recorded that "iron drawn by stone often follows it, but often also is turned and driven away"—the first differentiation between magnetic poles. But for centuries the world forgot.

Alexander Neckham, English monk, was among the first to reawaken the world to electricity. His treatise of 1180 discussed the mariner's compass, known to the Chinese (who apparently invented everything but the New Deal) since 1160 B.C., but still witchcraft to the twelfth-century Englishman. Petrus Perigrinus wrote on the same subject in 1269, also pursued that age-old lure, perpetual motion. He, Carden and Bishop Wilkins all thought of using magnets to produce it.

All sorts of ideas gained credence. There were supposed to be magnets able to attract gold, silver, lead, brass, water, even animals or fish, instead of iron, but they lost their power when smeared with garlic (for which they can't be blamed), regained it if sprinkled with goat's blood, unless a diamond were nearby. They were supposed to act as a love potion, to reconcile husbands and wives, even to test female chastity!

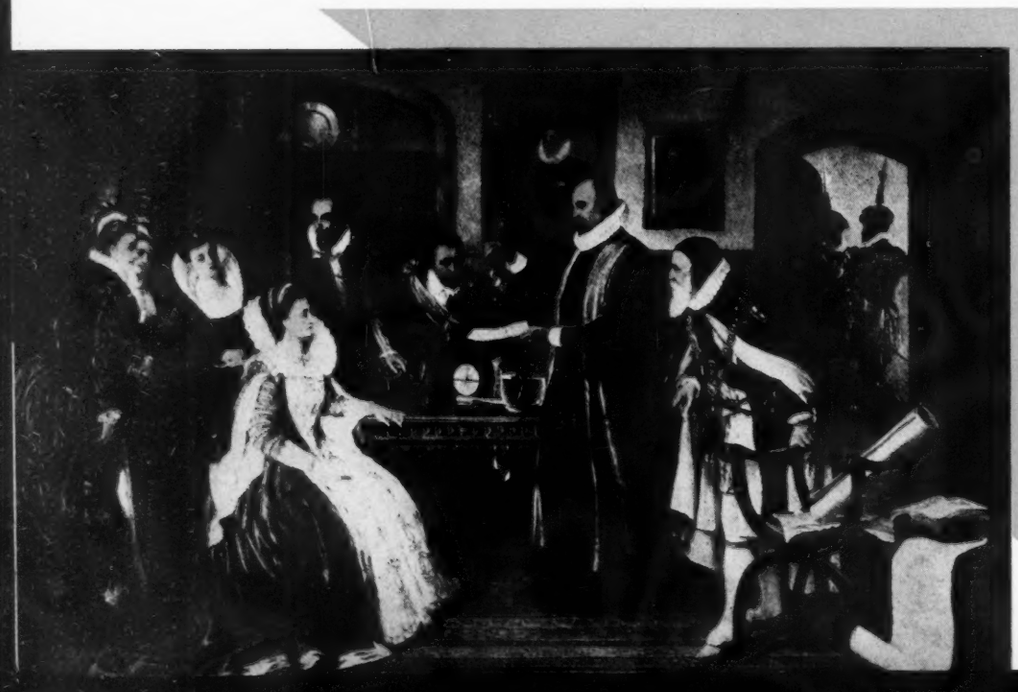
Georg Hartmann (1489-1564) first discovered magnetic dip and its variation, Columbus noticed magnetic declination, Robert Norman followed up magnetic dip about 1576 and deduced from it that the earth was really a huge magnet and that the magnetic and geographic poles were the same thing. But the man who was to clear up most of the mystery was a doctor—Sir William Gilbert, chief physician to Queen Elizabeth. "Good Queen Bess" noticed his great interest in amber, so retired him on pension to work with the idea. His "De Magneta" of 1600 listed diamond, opal, glass, sulphur, resin and mica as materials which attracted as did amber. He adopted the word "electrics" (Greek for amber) as a name for this group. His tests showed that amber lost its attractive power rapidly in wet weather, but kept it for as long as five minutes on a cool dry day. Mountains which drew nails from ships were all bunk, according to Gilbert, as were those "magnets" which attracted other materials than iron and the potency of lodestones in love.

Gilbert proved not only Neckham's assertion that a suspended magnet always points to the north and can magnetize a piece of iron temporarily but also that the magnetic force is throughout the mass, although strongest at the poles. He proved that when a magnet is broken, each part becomes a new magnet with north and south poles and that efforts to produce perpetual motion with magnets were unsound because magnetic attraction can only be insulated with iron itself. He proved further that an iron particle becomes magnetized before it touches a magnet, its induced polarity being opposite that of the magnet.

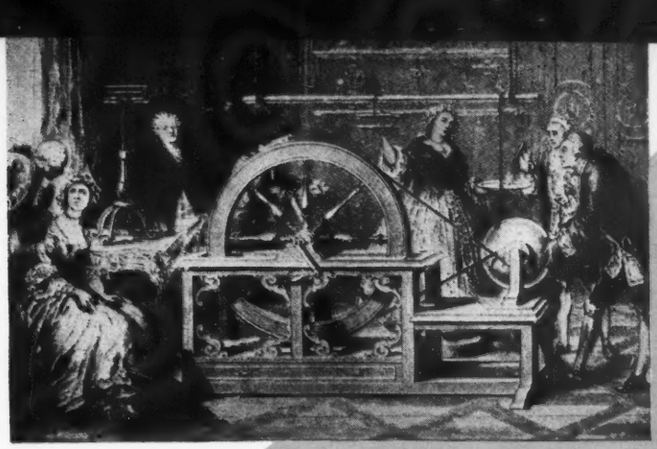
Nicolaus Cabaeus, Jesuit, 25 years later, corrected some of Gilbert's mistakes or omissions. He used iron filings to visualize magnetic lines of force, and his work "Philosophica Magnetica" pointed out that "electrics" might repel objects as well as attract them.

Otto von Guericke, burgomaster of Magdeburg, developed that revolutionary machine, the static electricity generator. In 1663, he took a ball of sulphur pierced with an iron rod carried on bearings, spun it rapidly with one hand and rubbed it with a piece of silk in the other. If a chain were hung so that it almost touched the ball, sparks flew, and if the globe were rubbed in a dark room it produced a glow—probably man's first generation of electric light.

Von Guericke proved Cabaeus right by causing his charged ball to repel a floating feather, and further made the ball alternately attract and repel the feather by positioning them both the proper distance above a table. Here was the first generator. He then sent the charge along a linen thread.



Sir Wm. Gilbert explains amber's mysterious power to Good Queen Bess



Otto Von Guericke demonstrates his static machine of 1650

Robert Boyle, inventor of the air pump, showed in 1675 that Cabaeus was wrong in believing that a vacuum affected the power of magnetism. He also first noticed ozone, which he considered an odor of the "electric."

Jean Picard reported about the same time a peculiar glow in the top of his barometer tube, brighter when the column of mercury descended more rapidly. Promptly, every other possessor of a barometer tried to get the same result, but no one had any luck until Jean Bernouilli, the mathematician, explained in 1700 that the tube had to be very dry inside and the mercury very pure.

Bernouilli's experiments started Francis Hawksbee, curator of the Royal Society, on a group of demonstrations which had that august body continually atingle between 1705 and 1711. He built a static generator which revolved amber in contact with wool. Again he got the light, but the speed was so high that the rubbing surfaces were charred. So he shifted to a design like Von Guericke's, but using an exhausted glass globe instead of the sulphur and hooking it up with a belt and crank to get speed. The resulting light was so bright that it lit the room and permitted large print to be read easily.

Stephen Grey, pensioner of the Charter House School, built a friction machine like Hawksbee's and Sir Isaac Newton's (improved design with glass cylinder instead of ball), then stood boys on cakes of resin and charged them by revolving the cylinder between their hands. These electrified boys could shock other boys not on resin. Further, not only would his charged glass cylinder attract feathers, but so would the corks at its ends, a 4-in. wooden rod in the cork, a longer rod, a wire, a long thread.

Of course the logical thing to do was to try longer transmission lines, so he strung a hempen cord by hemp loops from a beam. But there he ran into trouble, for its end showed no interest in feather or foil, no matter how mightily he twirled. With Wheeler, his associate, he pondered over the problem. Perhaps the hempen supports were the trouble. They shifted to silk, with the idea that "less virtue would probably pass off by it than by the thickness of the hempen line which had been previously used." It worked, but still Grey wasn't satisfied. He tried a metal wire instead of the silk for supports and the metal foil promptly lost interest. Here then was something. Apparently materials were not only electrics or non-electrics, they were also insulators or conductors. With this figured out, Grey and Wheeler transmitted the static charge 765 ft. through silk-suspended hemp and 866 ft. through silk-suspended wire in June, 1729, and August, 1730. And there grew upon Grey Hawksbee's and Newton's idea of kinship between lightning and the sparks he produced.

Meanwhile, the superintendent of gardens for Louis XIV, Charles Francois d'Asternay Dufay, was kicking up trouble in France. He decided that there were not only two types of electrics, but also two types of charges that made them act that way. He found that electrified gum copal, Spanish wax and amber all attracted gold leaf, while glass repelled it. A careful series of experiments with all sorts of electrics convinced him that if glass was rubbed with silk "vitreous" electricity was produced, while if amber, rubber, sulphur or resin were rubbed with fur, "resinous" electricity was produced. Soon the "vitreous" became "positive," the "resinous" "negative," the terms which are still used. Dufay determined that hempen thread supported by silk is "insulated," an "insulator" being a very poor conductor. He succeeded in sending a charge over a wet string 1,256 ft. long, even tried to collect electricity.

The scene shifts now to Germany and to the Scotch monk Andreas Gordon teaching at Erfurt. In 1736 he produced the first machine to use electricity—a simple bell. On a silken cord hung a small metal ball between two gongs. When the ball was charged by a rubbed glass rod, it promptly struck one gong, thereby losing its charge, then swung across and struck the other. Gordon kept on, producing a greatly improved static machine by using a 4-in. glass cylinder 8 in. long driven by a bow as an Indian drives a fire drill. This set-up gave him 680 r.p.m. Next he took a bit of metal and formed a crude star, pivoted at its center and with the points bent over to one side. If he sawed away at his static machine and directed a wire from it at a star tip, a spark would jump and the star would begin to spin from the reaction. As sparks kept jumping, it spun faster and faster—the first electric motor. Even that wasn't enough. He caught chaffinches and directed sparks at them. Feathers promptly flew and the birds were electrocuted most efficiently. It worked just as well to light alcohol and to fire guns.

Here was a tremendous new force, but how might it be stored? Men all over Europe puzzled over the problem; two solved it. Bishop Von Kleist, dean of the Cathedral of Camin, Pomerania, and Pieter Van Musschenbroek of Leyden, Holland, tried glass bottles filled with water as storehouses for static electricity. According to the stories, both discovered the truth the same way—but let's tell it about Musschenbroek. He connected bottle and static machine and began to twirl the handle. After a while he

decided the bottle should be charged. It was. When the good Pieter touched it, it promptly slammed him into a corner, a sadder and wiser man.

Von Kleist, meanwhile, had done somewhat the same thing Oct. 11, 1745, testing the strength of the spark by breaking wine glasses and lighting spirits of wine with it. But Pieter's experiments were better publicized, so men began to call it the Leyden phial, then the Leyden jar.

Sir Wm. Watson and Dr. John Bevis disposed of the water and other paraphernalia and covered the bottle to half height inside and out with tinfoil. In this form it became the pet tool of experimenters, although some of them used it to produce effects not unlike Monk Gordon's "silly" toys. Jean Antoine Nollet, French abbê, had a company of the king's men join hands, then knocked 180 of them flat with a jolt from a well-charged jar. Not content with that, he lined up a mile of Carthusian monks and sent a shock for the length of the line.

Meanwhile Sir Wm. Watson and a committee of the Royal Society had begun experiments to find out how big a charge could be gotten from a Leyden jar, how far it would travel, and how long it took. First they transmitted a charge across Westminster Bridge (July 14 and 18, 1747), then through 2,000 ft. of land and 800 of water at New River (July 24), and a little later on the same day through 8,000 ft. of water and 2,800 of land—a bit over two miles. But the time no man could tell—apparently it was nothing (actually about one hundred-thousandth second). At Shooter's Hill, Aug. 5, 1748, Dr. Watson raised the figure to 12,276 ft., but again could not record the time.

With that Dr. Watson went wild. He tried sending the charge through a vacuum, then through a 7-year-old girl seized with some sort of epileptic disorder. Apparently it cured her after a couple of months, although she may have gotten well in order to be let alone. Of course this miraculous cure made the jar suitable for all sorts of medicine—even dentistry. Dentists simply connected a pair of wires to an aching tooth, then touched them to a charged jar. Promptly the patient forgot all about the toothache.

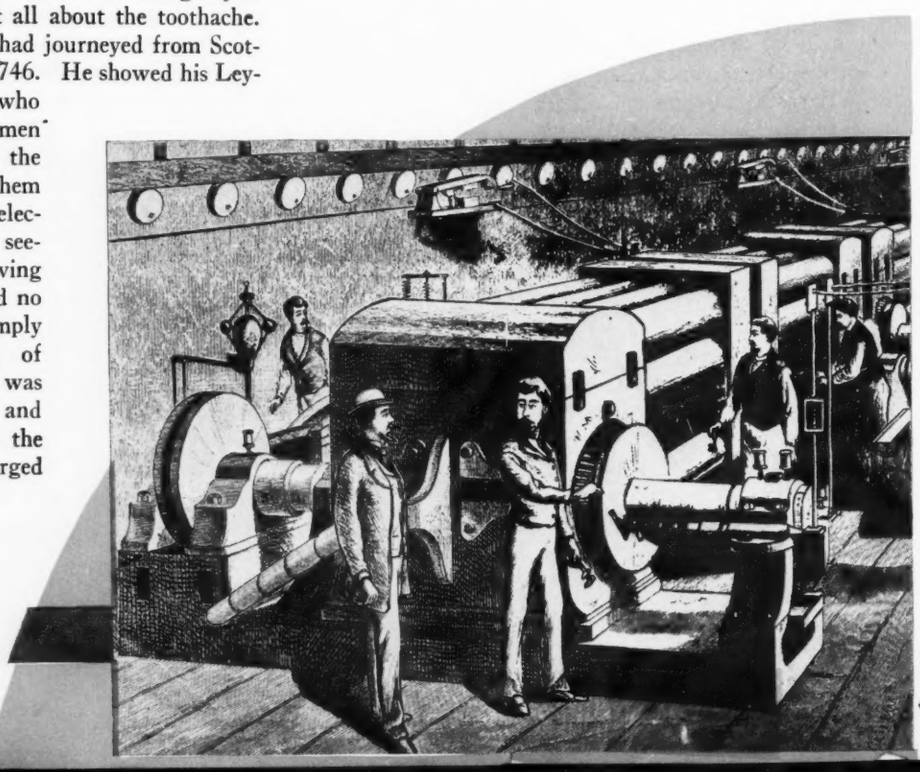
It seems that Dr. Spence had journeyed from Scotland to Philadelphia about 1746. He showed his Leyden jar to Ben Franklin, who promptly started to stand men on cakes of wax to find the electrical charge from them under varying conditions, electrifying a jet of water and seeing it break as a result, proving that a charged jar contained no new material, that it was simply a matter of distribution of fluids. The inner coating was positive, the outer negative, and if one were connected to the other, the jar discharged just as if it had been touched to ground. He hunted for the storehouse of the electricity, finally not to find it in the foil at all, but on the *surface of the glass.*

Franklin went on with his experiments. He tried the Monk Gordon's stunt of electrocution, only Franklin used *six* jars to jolt a turkey into eternity. Then he tried his famous kite experiment—after searching unsuccessfully for three years for a sentry box atop a lone hill or a suitable church spire. In June, 1752, his son helped him fly his silk kite from Philadelphia Common into a drenching rainstorm. Nothing happened until the string became wet, for Franklin had carefully wrapped his hand in a silk handkerchief and dangled the key up the cord a little distance. But when the string became damp, a spark jumped from key to knuckle—proving the belief of Hawksbee, then Newton, then Franklin, that lightning and electricity were the same thing. Why Franklin didn't share the fate of his turkey and Gordon's chaffinches, nobody knows. He promptly commercialized the result by inventing the lightning rod.

Naturally, with such stunts, serious-minded people began to consider electricity as a toy. But Jesse Ramsden built a plate electrical machine which produced much heavier sparks than the cylinder-type machine, and Curate Abraham Bennet of Wirksworth designed the electroscope in 1787.

Dr. Luigi Galvani of Bologna, while working one day in 1785 on the nervous system of a frog, cut deep into the frog's leg muscles, so deep that his probing scalpel touched a wire below. Now that wire was fastened to his friction machine (all fashionable doctors had them then) and his assistant had been turning the handle idly. Promptly that frog's legs kicked. Galvani jumped, crossed himself and tried again, and yet again. Each time the frog leg did the same thing. Of course the answer was obvious—electricity and life were the same thing.

When Galvani told, scientists all over Europe began slaughtering frogs by the dozen. But no one



found out why the legs kicked. Galvani found that legs hung from a copper hook kicked spryly when the hook touched an iron grill (the principle of the battery, if he had but known), but Galvani decided that this was because the life of the freshly killed frog had not entirely ebbed. The only doubter was Alessandro Giuseppe Antonia Anastasia Volta of the University of Pavia, who explained that the legs kicked because something outside stimulated them, probably the combination of different metals. But not until two years after Galvani died could Volta prove he was right.

He did it with the voltaic cell, a pile of alternate copper coins and zinc disks, separated by moist cloth. Wires from the top coin and the lowest zinc disk, when touched simultaneously to a frog leg, produced a magnificent kick. This first direct-current producer had 100 disks, but soon Volta had one of 500, using sulphuric acid instead of water on the sandwiched cloth to increase the flow. But the pile dried out too rapidly, and when it did, the flow of current stopped. So Volta substituted cups filled with acid, a strip each of silver and zinc in each cup. Connecting 20 cups in series permitted Volta to decompose water. Not content with that, he tried it on heads of hanged criminals, on crickets to make them sing louder, on bettles to increase their luster.

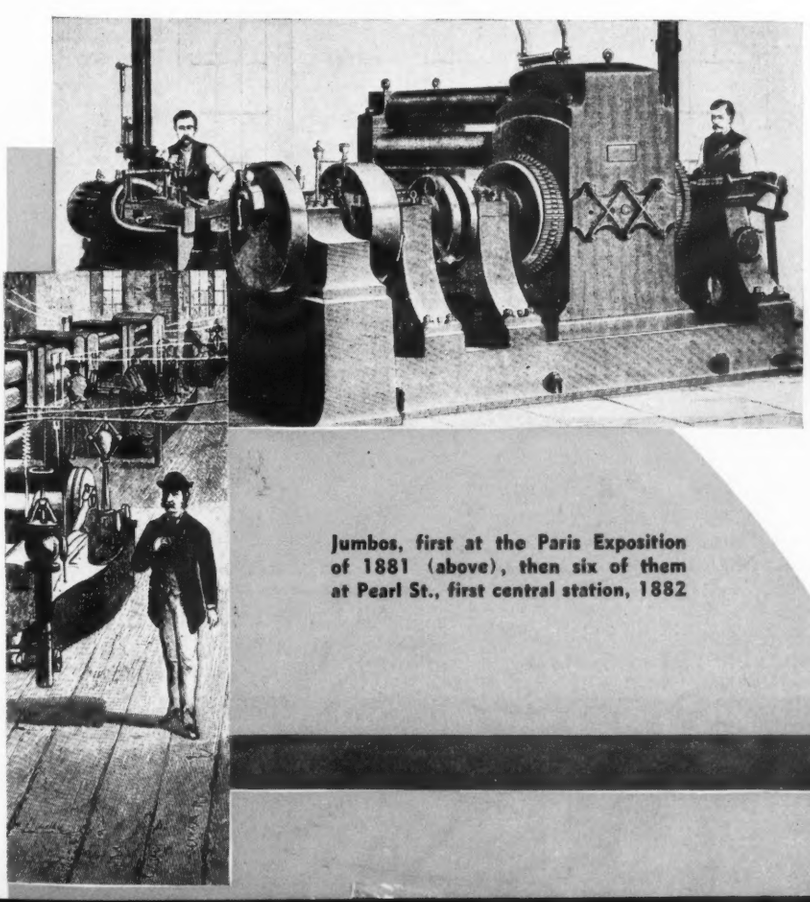
Others went ahead with more practical work, designing the "plunge battery" which had a simple frame to lift the zinc from the acid when it wasn't in use, rubbing the zinc with mercury to form an amalgam which protected it except when current was being used. In 1800, Nicholson and Carlisle also decomposed water, using a pile of 36 half-crowns with zinc disks, separated by paper soaked in salt water. Sir Humphrey Davy, in 1802, used a 2000-couple pile to light an arc before the Royal Society.

Now it is time for the Dane, Hans Christian Oersted, who first pointed out that electricity and magnetism were one and the same thing. His father, the village apothecary, had always been interested in the "electric flow." The educated Hans inherited his curiosity. As soon as he heard of Volta's pile, he tried it, but without much success. Oersted had one certain belief—that the voltaic pile and magnetic attraction had something in common. For thirteen years he thought that, then found the truth—in 1819—entirely by accident. He had decided to show his class of advanced students one day how fine platinum wire will glow when connected across the terminals of a battery. In the midst of his lecture, a small compass on the desk got in his way, so he moved it *under the wire*. The needle, which usually pointed resolutely to the north, suddenly swung foolishly to the south.

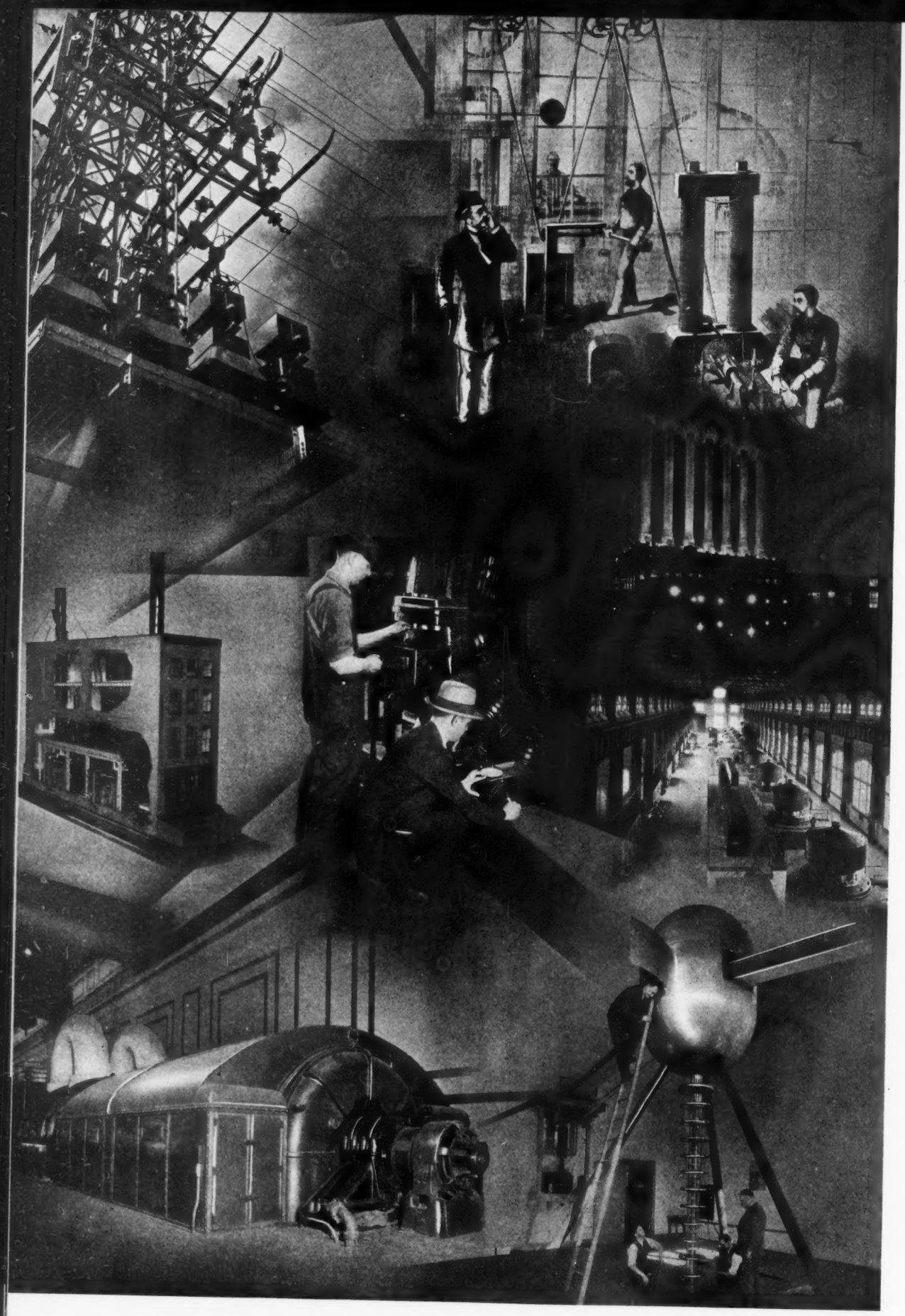
Oersted finished the lecture, then sat down and tried the stunt again, first with the wire connected, then with it disconnected. Sure enough, current had to be flowing. Bigger batteries simply increased the deflection of the needle. July 21, 1820, Oersted published a comprehensive tract in scholarly Latin, explaining that electrical flow in a conductor produced a magnetic effect in a circular direction around the wire which caused a magnet to point 90 deg. to the direction of the current. Furthermore, if the flow were reversed, the needle also reversed itself.

Scientists throughout Europe set off on the new trail like hounds after a fox. But the fox led them a merry chase—for one short week. Then Andre Marie Ampère caught up with him. Ampère, two years older than Oersted, had been a child prodigy who studied addition with crumbs instead of eating them and who tried at 12 to understand the complex theories of Euler and Bernouilli. By 1802, he had prepared a paper proving what no gambler will believe—that the odds are always against the winner. Sept. 11, 1820, when Oersted's discovery was announced to the French Institute, Ampère was there.

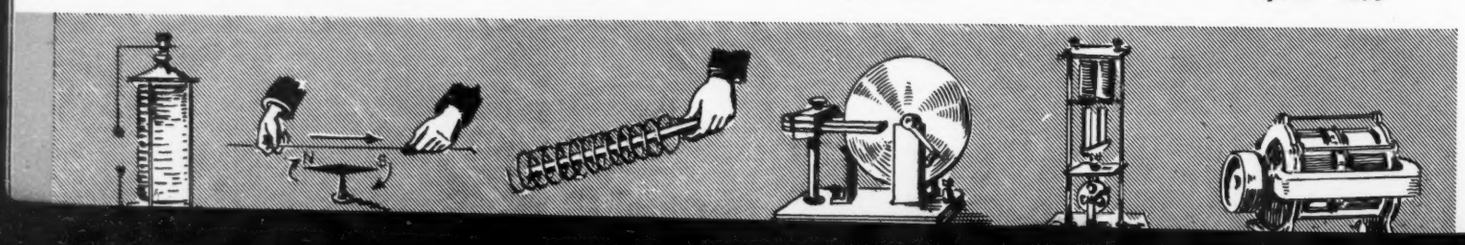
His great life work occurred during the next seven days, for at the end of that time he had the answers to most of Oersted's questions. The Academy wouldn't believe him, but he told them these things: Two parallel wires carrying current attract each other when the currents in both flow the same direction, repel otherwise. A coil of wire with a current passing through it acts exactly like a permanent

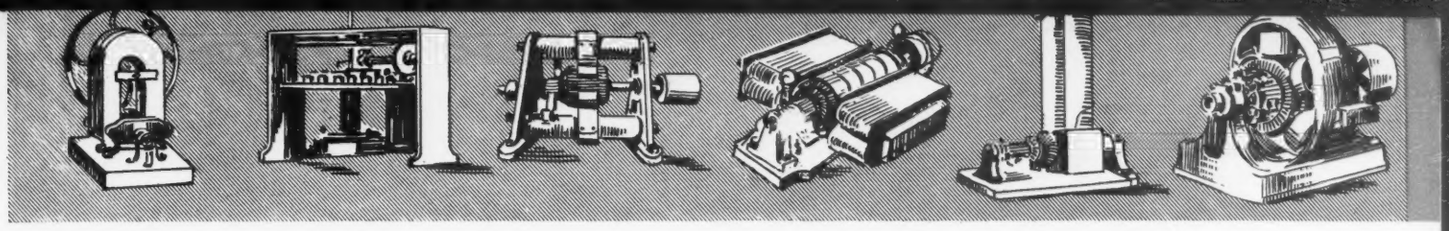


Jumbos, first at the Paris Exposition of 1881 (above), then six of them at Pearl St., first central station, 1882



Volta—1799 Oersted—1820 Ampere—1820 Faraday—1831 Pixii—1832 Hjorth—1855



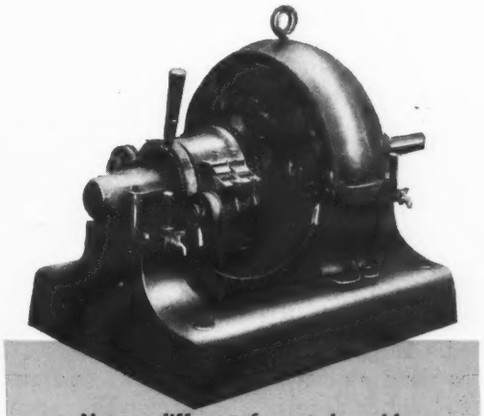


Siemens—1856 Pacinnotti—1865 Gramme—1871 Alteneck—1872 Edison—1882 Multi-polar—1890

magnet and has north and south poles. A bar of soft iron can be magnetized if thrust into such a coil. Deflection of a compass needle under the influence of a current he explained in the famous rule, "Imagine yourself swimming in the wire in the direction of the current and facing the needle, then the north pole will be deflected toward your left hand."

Next of the pioneers was Georg Simon Ohm, son of a Bavarian locksmith, who was eleven when Volta made his first pile. In 1827 he was a teacher of mathematics in a Jesuit school, impressed by Fournier's demonstration that the flow of heat in a metal was proportional to the difference in temperature between the ends. Somehow, his mind coupled this fact with the flow of current in a wire and promptly discovered that the flow of electricity in a wire depends on the difference in potential between its ends and that when the difference in potential was held constant the flow of current varied inversely with the resistance of the wire. Here was Ohm's Law—the basis of modern electrical engineering—although for a long time no one would believe it.

Electro-magnets trace their discovery to one Sturgeon, who in 1825 found that a round iron bar placed within a solenoid acquired a magnetic strength many times that of the solenoid alone, and lost it as soon as current was turned off (Dominique François Jean Arago had magnetized a bar of soft iron 5 years earlier by surrounding it with charged wires). By 1830 an electro-magnet of 700 ft. of copper wire and weighing 60 lb. supported a ton when energized by a few batteries. Schweigger produced the "multiplier," a fancy name for our modern galvanometer; John Frederic Daniell developed the voltaic pile into a battery capable of giving steady current for some time. Sir William Robert Grove took Daniell's cell of 1836 and made of it in 1840 a platinum-zinc battery with almost double the voltage of earlier cells. Many years later Grenet substituted carbon for the platinum and potassium bichromate for the nitric acid.



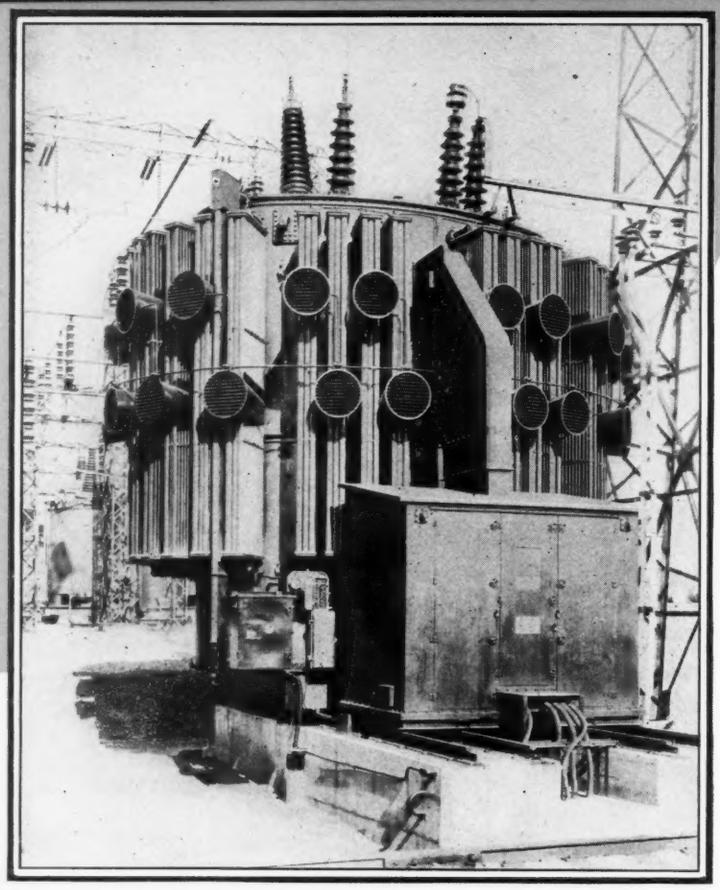
Not so different from today—M. E. Thompson's pioneer 10-kw. compensated d.c. generator, 1894

Benjamin Thompson, born an American, but later Count Rumford who founded the English Royal Institution, had discovered the young Cornishman, Humphrey Davy, who invented the miner's safety lamp, laughing gas, and also found the tremendous power of electricity in decomposing chemicals and the heat of its arc, capable of melting most of the then-known elements, including platinum. His studies were the basis for Joule's work in 1842, upon which successful operation of modern electrical heating devices depends.

But Davy's greatest discovery was Michael Faraday, the bookbinder's apprentice. This blacksmith's son, born Sept. 22, 1791, had first gone to work at seven as a newsboy, but even then was precocious enough to put his head through the bars of an iron fence and ask, "Now, which side of the fence am I on?" The owner of the fence soon settled that question, but others crowded in on him when at thirteen he became apprenticed to a bookbinder. For Michael did one thing that no bookbinder's apprentice is supposed to do—he read everything he bound. At eighteen, he was eagerly listening to lectures on "natural philosophy" and building voltaic cells. At twenty-one, he was listening to Humphrey Davy himself, taking careful notes which he forwarded to Sir Joseph Banks, co-founder of the Royal Institution, as a reason for giving him a job. But he got no answer.

Next he wrote Sir Humphrey Davy, and this time at least got an interview. When he got it, he asked Davy if he might work for him, if only as a bottle-washer, but the blacksmith's son was a little too crude for the genteel Davy. Providence promptly intervened, for Davy, experimenting with that unstable compound, nitrogen trichloride, was temporarily blinded in one eye by a sudden explosion. This was March, 1813, and Davy had much to do. In his extremity he thought again of Faraday, who wrote such a neat hand. Six months as Davy's assistant, and Faraday traveled throughout Europe with him, even though Lady Davy thought him so unkempt she made him eat with the help.

By 1821, Faraday had shown so much promise that he was embarked upon original research, doing a lot of worrying about Oersted's discoveries and Ampère's explanations. Oersted had said that "the electrical conflict acts in a revolving manner" about the conductor. Faraday promptly set a bar magnet vertically in a pool of mercury with a copper conductor hanging from above it and dipping into the mercury. The copper and mercury he connected to a voltaic cell; the conductor immediately began a careful rotation about the magnet. Even the stolid Faraday was



Alternating current is tailored to fit the job in hand by the modern transformer

so excited that he danced about the table and cried, "There they go! There they go! We have succeeded at last!"

Within the next few months, his experiments had convinced him of these three great electrical laws:

Under the influence of electricity, a wire will rotate around the pole of a magnet. If the wire is fixed and the magnet free, it's pole will rotate about the conductor. Direction of rotation is reversed in either case if battery connections are reversed.

The work he did, based on these three laws, got him a fellowship in the Royal Institution in 1824, but Faraday still was not satisfied. Electricity obviously produced motion; why then shouldn't motion produce electricity? Not until 1831 did he discover the means for finding this out. In that year, he wound two separate coils of wire about a soft iron ring, one coil in circuit with a battery, the other with a galvanometer. He closed the battery switch, the galvanometer needle promptly jumped, but *it came to rest again*. Faraday was disappointed, to say the least. Sadly, he opened the switch, and *the needle jumped again*. There, in two jumps was the answer he was looking for (he missed his unwitting discovery of the transformer, not to be rediscovered for fifty years)—induction depended on starting and stopping the current as well as on propinquity of coils.

Five days more (Sept. 3) and Faraday was ready for the next test, with a 220-ft. coil of copper wire and a bar magnet of dense black iron, $\frac{3}{4}$x8$\frac{1}{2}$ in. He connected his coil to the galvanometer, then thrust the magnet quickly through the coil. The needle flickered — Faraday's answer was complete. The conductor had to *cut* the magnetic lines of force.

Now to get continuous current. Faraday took a 12-in. disk of copper 1/5 in. thick and mounted it on a shaft between the poles of a horseshoe magnet. Wires from his galvanometer led to a brush touching the edge of the disk and to the axle. Here was a conductor continuously cutting lines of force, and it produced exactly what Faraday had hoped for—constant deflection of the galvanometer needle as long as the disk was rotated. He had invented the dynamo. But Faraday didn't carry it on to perfection. A pure research man, he left it for others to perfect. It took them forty years.

A year after Faraday's invention of the principle of the dynamo, Hippolyte Pixii, a Frenchman, combined Faraday's scheme of moving a permanent magnet near a coil of wire and Sturgeon's scheme of strengthening magnetism in a coil with an iron core to produce a dynamo much better than Faraday's disk machine. Pixii's machine of 1832 consisted of a permanent horseshoe magnet with its ends rotated about the ends of two coils of wire mounted on a soft iron core. He used a commutator to obtain d.c. from the a.c. thus generated. Two years later, the Englishman, E. M. Clarke, made several dynamos like Pixii's, except that he rotated the coils of wire alongside the poles of a stationary horseshoe magnet.

Both types of machine naturally produced a current pulsating in voltage. Woolrich doubled the number of coils and increased the number of magnets in 1841, five years later Wheatstone replaced the permanent magnets with electromagnets. Brett, in 1848, suggested that the current from a permanent magnet machine be sent through coils surrounding the magnets in order to increase output. But still eddy currents in the iron caused it to heat until Pulvermacher proposed laminated cores in 1849. Sinstenden, two years later, proposed that current from a permanent magnet machine be used as excitation for the field coils of an electro-magnet machine—the birth of the separate exciter.

Meanwhile, Joseph Henry, the American, had discovered many of Faraday's principles almost simultaneously, and had aroused interest in this country in magnetism. Thomas Davenport, village blacksmith at Brandon, Vt., was one of those who became intensely interested in Prof. Henry's magnets, so interested that he immediately began planning a crude motor. By 1834 it was finished and hooked up to a voltaic cell. It worked, but armature insulation was poor. He needed a bigger machine with better insulation. The story is that he purloined his wife's wedding dress, arguing that she hadn't used it for eight years and was too fat to wear it anyhow. Every foot of wire in his new armature was carefully wound with strips from the dress, so carefully that it worked. Right there Brandon lost a good blacksmith and the world got a good electrical engineer.

In 1855, Hjorth patented a dynamo with both permanent and electro-magnet field poles, probably the first self-excited machine. Dr. Werner Siemens followed in 1856 with the shuttle-wound armature in which the armature coil was countersunk into the iron core and the magnet poles were shaped to surround it. Nine years later, Antonio Pacinnotti produced a d.c. dynamo that was somewhat better (with probably the earliest multi-segment commutator and first which would run either as generator or motor), but it was not until 1870 and the work of the Belgian, Z. T. Gramme, that the dynamo began to come into its own. Gramme developed the "ring-wound armature, consisting of a ring-shaped core of iron wire coated with an insulating compound to reduce eddy currents and wound with insulated copper wire coils connected in series, each coil being tapped with a wire connected to a commutator bar. Here at last was a steady flow of current which could be used for arc-lighting and similar tasks.

Shortly before that, Wheatstone invented a self-excited machine using residual magnetism in the field poles to set up a feeble current in the armature which, passing through the field coils, gradually builds their strength up to normal. His first machine was built in 1866, and exhibited the next year at a meeting of the Royal Society at which a paper from Dr. Werner Siemens was read describing exactly the same invention. Von Hefner Alteneck, an engineer with Siemens, invented the drum-wound armature in 1872, with wires all wound on the surface of the armature, the wires being tapped frequently for connection to the commutator bars, a principle still used.

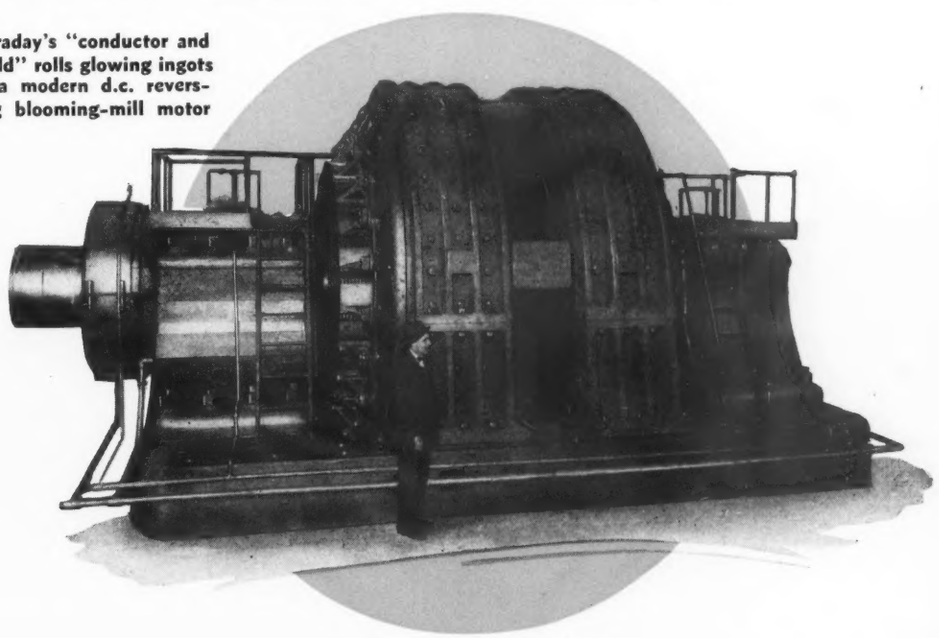
Gramme, meanwhile, had been working steadily and had become so well known that his generators were to occupy the position of honor at the Vienna Industrial Exposition of 1873. He had set up two dynamos side by side; one was already running, driven by steam engine. The other has not yet had its driveshaft connected. A sleepy workman, not watching his business, connected wires from the moving dynamo to the one standing quiet. Suddenly the quiet dynamo was quiet no longer. Gramme looked at it for a minute and realized the truth—a dynamo and a motor were the same thing.

Now we come to Thomas Alva Edison, who in the year when Gramme's workman misconnected his dynamo, was about 25. Edison, experimenter grown from a candy butcher on trains, was already becoming known for his inventions. He came upon a report of the Franklin Institute of Philadelphia lauding the Gramme machine, which said, "It utilizes in the arc (lamp) from 38 to 41 per cent of the motive power produced, after deduction is made for friction and the resistance of the air." Edison already had a successful incandescent lamp; here apparently was the machine he needed to make the lamp a commercial success. He set to work, driving an armature at varying speeds with different types of windings, until in 1879 he had one which he claimed showed 90 per cent efficiency. The thing to do now was to get people interested, so Edison decided to build a great bi-polar dynamo for the first electrical exposition in Paris, to be held in 1881. This was to be the first of the famous "Jumbos." And a Jumbo it was, for it weighed 27 tons and could light 1,200 lamps. The armature alone weighed six tons. But even a Jumbo has its growing pains. First its voltage was low, which meant that the machine had to be torn apart and changes made in the magnets. Then it was the crankshaft, which threw itself all over the shop. When that was fixed, only three days remained before the Jumbo had to be shipped.

Edison had still to test his machine, a job which would take all the remaining time. But even in adversity, Edison was a showman, so he appealed to Tammany Hall (which many New Yorkers have done since) to line the route from shop to ship with police, so that his horse trucks could dash down with their load. Four hours before the latest possible loading time, the machine was shut down and sixty men set to work to take it apart according to a prearranged schedule. Headed by a fire bell, his trucks dashed to the pier, where sixty men helped the stevedores to load it—just an hour before the ship sailed.

As soon as the Jumbo was on its way to Paris, Edison was at work on two more machines in the old Aetna Iron Works (renamed "Edison Machine Works") for a plant at Holborn Viaduct in London. Set up on Crown land and started on a 3,000-lamp load, Jan. 12, 1882, it was to be the first central station. But politics stepped in—the Electric Lighting Act of 1882 killed the plant in favor of gas lights (themselves only 60 years old).

But legislators couldn't stop the idea now. In Meisbach, Bavaria, a small hydro-electric plant sent

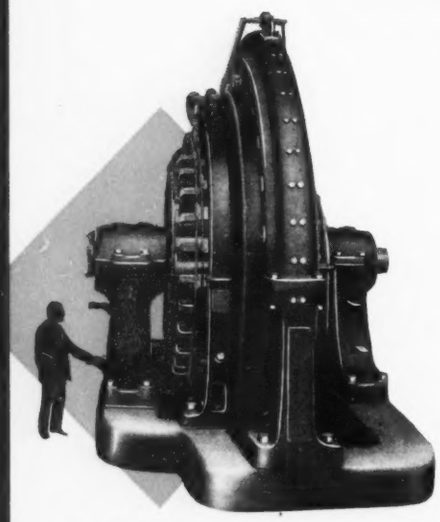


Faraday's "conductor and field" rolls glowing ingots —a modern d.c. reversing blooming-mill motor

current over iron wires into Munich, soon to be followed by America's first, Oct. 15, 1882, at Appleton, Wis. There a tiny dynamo in a wooden shed lit 250 10-cp. lights. But Edison himself had meanwhile started the first central station—Pearl Street, in New York. His original plan was to build a plant big enough to light the area from Wall St. to Canal St., but it became a square mile. By May, 1882, three Jumbos were installed at 257 Pearl St., the largest 125 hp. July 5 they were started at 220 volts, July 8 they lighted 1,000 test lamps in the station. Sept. 4, the new plant began to supply its first customers, 59 of them, all promised three months of free current. Within four months, the company was lighting 5,000 lamps in 225 houses.

But each Jumbo still ran alone on its own circuit. Edison believed that they could be run in parallel. Finally, one Sunday he tried it, and in his own words "Of all the circuses since Adam was born, we had the worst then!" One engine would stop and the other run up to a thousand revolutions, then they would see-saw, the trouble being with the governor, and with the motors, which were alternately running each other. Not for some time did he try it again.

Many are the stories of happenings in that early plant. One order for 250 lamps interested Edison so much that he investigated. He found that the purchaser wanted to take the "shudder" out of cheap "rot-gut" whiskey, using clusters of bulbs to accelerate aging. Edison was a business man as well as a temperance advocate, and in this case business won.



Twisting a.c. into d.c. Modern 6825-kw. rotary converter

Even J. Pierpont Morgan once objected to his bill. Edison was then using meters he had invented himself—chemical arrangements which measured current by the amount of metal deposited on a plate. Edison was sure the meters were right, so he tagged every lamp in the Morgan establishment, the idea being that the time each light was on was to be noted on the tag. But even at that more current was apparently being used than the tag showed. Edison finally found out that the cleaners were the offenders, for they burned lights most of the night, but hadn't been told of the tags. Morgan paid his bill.

Electricity was now definitely practical, the principal argument being whether it should be a.c. or d.c. Lord Kelvin and Edison argued for d.c., Elihu Thomson and Nikola Tesla for a.c. Kelvin and Edison argued that motors wouldn't run on a.c., nor could batteries be charged. But Thomson countered with a three-coil dynamo in 1879 (a d.c. machine which pointed the way to a.c. units) and the repulsion motor, granddad of single-phase induction motors.

Tesla announced to his professor as early as 1878 that brushes ought to be eliminated. By 1881 he had developed a brushless motor, but couldn't find time to build it until 1882. In 1883 he built two more, in 1884 sought for capital in Paris, and finding none, resolved to come to the United States, where he'd heard money grew on trees. About the same time the Englishman Gibbs and the Frenchman Gaulard had taken Faraday's old idea of two coils wound on a soft iron ring and made of it what they called a secondary generator—our now-familiar transformer. They found that the higher the voltage in a transmission line, the more efficiently the current was transmitted, thus a "step-up" transformer at one end of a line and a "step-down" at the other made it possible to make the line in between much longer.

George Westinghouse brought this idea back to the United States, and with William Stanley, Jr., worked on it. They finished an experimental installation at Great Barrington, Mass., March 16, 1886, with which they stepped current up to a thousand volts, sent it over a 2-mile line (twice as long as any earlier) then stepped it down again to light 300 lamps. Here was half the answer, and about that time Westinghouse met Tesla, who supplied the rest of it. By Nov. 30, the first a.c. central station was in operation in Buffalo; nine years later Tesla two-phase alternators built by Westinghouse produced the first real current from Niagara. They were 5,000 hp., ten times as large as anything previously built.

Another man, Benjamin Garver Lamme, deserves much of the credit for what was done at Niagara. He went to work for Westinghouse after graduation from college in 1888, first as an oiler at $30 a month. But he was too good a man for the job, so soon was transferred to the testing department. There one day he absent-mindedly scrawled the sign of the calculus—mark of the technical man—on a piece of paper which his boss saw. That landed him in the design department, just before the work began on generators for Niagara. Lamme's tests showed that alternators could stand 40 to 50 per cent more capacity than an equal-size d.c. generator. That was the deciding *factor*. It was Lamme also who designed the largest, and one of the last, installations of its kind, the eight 40-ft., million-pound reciprocating-engine driven alternators for the New York elevated railways. Installed in 1903, the units turned at 75 r.p.m. to produce 5,000 kw. apiece.

But now the turbine was becoming known, and Lamme had a chance to exercise his boyish yearning for high speeds. Even as early as 1898 he had hooked up turbine and generator to run at 1200 r.p.m.

From that little start of about thirty years ago developed the great turbo-generators which with hydro-electric plants, only a dozen years older, supply the great proportion of our present-day power.

POWER'S STORY

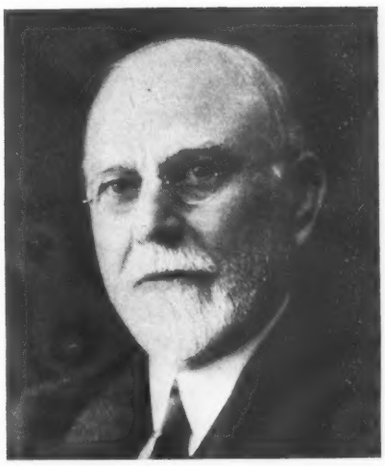
EIGHTEEN hundred eighty-four. Chester A. Arthur is in the White House; Grover Cleveland impatiently awaits nomination. Thirty-eight states form the Union; in some of the others troops still fight Indians. In the cities, horse cars, omnibuses and victorias dot the cobbled streets. Silk-hatted or square-derbied business men talk with side-whiskered professional men.

Niagara Falls roars in solemn grandeur, untapped for power except for one or two puny waterwheels on a toy canal. The Centennial Corliss is still an object of awe, the steam turbine little more than a fascinating toy. Wheezy steam engines are served by long lines of little horizontal boilers, stoked hour after hour by sweating men stripped to the waist. Engineers are hard-bitten practical men; scientific knowledge is only for professors.

The *Boston Journal of Commerce* ("Cotton, Wool and Iron") and similar journals in other towns give hesitant instruction to steam-plant engineers. In Chicago a writer named Hawkins struggles with the little two-year-old magazine *Steam*. Its first number, October, 1882, had advocated a national association for stationary engineers.

Back on the *Boston Journal of Commerce* two young men sell ads and write news for the steam-plant section. They dream of a new power magazine to be devoted entirely to serving steam-plant men as a group. 1884 finds these two, Emerson P. Harris and Horace M. Swetland, working shoulder to shoulder in New York—translating the dream into reality—laying the ground work for the new monthly *Power*. The partners purchase *Steam*. In November, 1884, they publish the first number of *Power with which is incorporated Steam*.

Offices are set up in the old Stone Building at 32 Liberty St., with flickering gas lights in flossy fixtures, one-sided heating from a coal stove, no telephone, two rackety typewriters. Besides *Power*, the *American Journal of Railway Appliances* and the new *Street Railway Journal* are published.



James H. McGraw, Chairman of the board, McGraw-Hill Publishing Company, with "Power" in 1884 as in 1934

One of the first additions to the staff was James H. McGraw, a former pupil of Swetland at Panama, N. Y. He started June 20, 1884, as subscription salesman out of the Philadelphia office.

October, 1886, found the company moving to 113 Liberty St. But debts piled up until there was a thousand dollars difference between assets and liabilities. The paper supplier threatened suit. Both partners had used all the money they could get. McGraw, sent for in the emergency, borrowed $1,000 from his old friend, James Knapp of Panama, offering no other security than his good name, and an insurance policy of which Knapp was made the beneficiary. That thousand dollars was McGraw's first investment, the beginning of the McGraw-Hill Publishing Company of today. In December, 1886, McGraw became secretary, in July, 1887, vice-president.

The subscription list was now 13,000, with 11,000 paid. "Readers' Problems" and "New Equipment" were already firmly intrenched. March, 1887, found the firm hunting a new office boy. Chester W. Dibble, hired at the princely salary of $2.50 a week, has been with the paper ever since, first as office boy, then assistant editor, finally assistant business manager.

Robert Grimshaw edited the infant *Power* from

Out West, troops were still fighting Indians

The Nineties — Fred R. Low (center) discusses "Power" with his staff, Robbins (left) and Dibble (right)

1884 to 1886, George L. Fowler until May, 1888, then A. D. Risteen until August of that year. Franklin Van Winkle pinch hit as editor between times. Swetland, meanwhile, had a feeling that editorial content might be improved. He wrote a young man on the *Boston Journal of Commerce,* Fred R. Low, enclosing the current issue, and asking for suggestions. He got them—so complete, sensible and illuminating, that he immediately wrote back and offered Low the job of editor. Low took it.

Born April 3, 1860, in Chelsea, Mass., Low had little formal schooling. Illness forced him to leave school at 14, so he became a Western Union clerk, learning telegraphy and stenography. 1878 found him a court and commercial stenographer, 1880 personal secretary to Editor Thomas Pray of the *Journal*. Pray had written a book on the then new steam-engine indicator and was mightily interested in the budding field of power. Thus, when Low walked in one morning with a copy of Barnaby Rudge under his arm, Pray yelled, "Why the hell don't you read something that will make you worth more around here!", pitched the book in a corner, and handed Low Zeuner's *Valve Gears*.

Low found Zeuner interesting, demanded more power information. Pray showed him the possibilities of the indicator. Low bought one. As he ferried, day after day, between Chelsea and Boston, he swapped stories with the engineers and firemen and indicated their engines. He joined the new National Association of Stationary Engineers.

Fred Low was editing the steam plant section of the Journal when he accepted Swetland's call to be editor of *Power*. Under his leadership the field of the magazine was to be broadened, without changing its practical approach, to serve the needs of professionally trained power engineers, designers and consultants. He was to serve as editor for 42 years.

Low has never lost touch with the practical enginemen, his friends in the early days. His career has been outstanding as much for his personality and friendships as for his achievements in engineering and journalism. A man of few words, his simple directness and practicality in speech and writing, and his fund of rich humor, have all endeared him to power engineers everywhere.

Low always had the courage of his convictions. Thus we find him hammering at state licensing laws and the frequency of boiler explosions, insisting that states should take more responsibility. 1894 brought waterwheels into the editorial columns, 1897 found Low arguing for direct-connected "steam dynamos" publishing the first Boiler Code, 1900 brought articles on mechanical refrigeration, gas and oil engines. In 1901 Low was urging recognition of the turbine, showing a definite place for superheated steam.

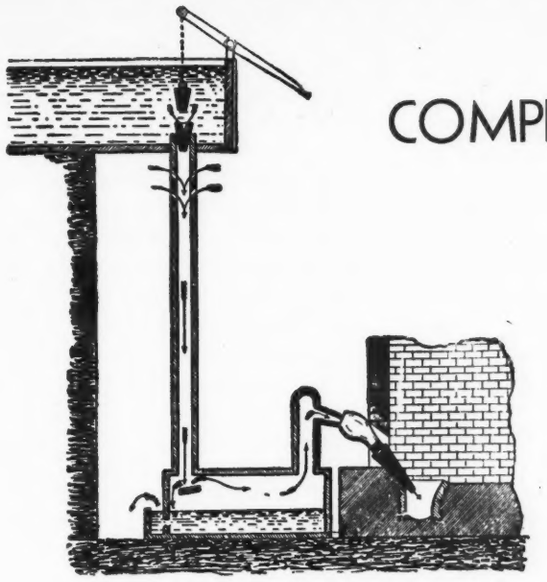
John A. Hill bought *Power* in 1902, bringing a more readable typographical style, a standard size (9 x 12 in.) and telephones. In 1903, *Power* absorbed *Science and Industry,* in 1908 it added the *Engineers' Review of* Cleveland and *The Engineer* of Chicago. At that time, the paper became a weekly, the title changed to *Power and The Engineer.* In 1911 the title again became *Power,* but the weekly publication continued until July, 1932.

In 1931, at the age of 70, Fred Low retired to become editor emeritus, leaving *Power* an institution permanently shaped to practical ends and human viewpoint: Since the day of his active leadership, new ideas and techniques of presentation have been constantly incorporated to meet the growing needs of an expanding power world. Yet these changes have always been grounded in the original concept of practical service to the men who design, construct and operate power plants.

After Mr. Low's retirement, Ely C. Hutchinson was editor until he resigned in January, 1933, to become president of a boiler manufacturing company. Philip W. Swain, managing editor, and with *Power* since 1921, then took active charge, becoming editor Jan. 1 of this year.

Of the original pioneers, three remain, and of these, two are today active in the affairs of the magazine: James H. McGraw, as Board Chairman of the McGraw-Hill Publishing Company, and Chester W. Dibble, assistant business manager of *Power*. This writing finds Fred Low still confined to his bed after a long siege of severe illness, yet his early vision and his present suggestions still inspire *Power's* staff.

By-product heat in the winter of 1882



COMPRESSED AIR

AIR-TREADING bags, wooden cylinder and piston, and Chinese windbox, still common primitive methods of producing an air blast, were known at least two thousand years before Christ. The bellows was confined, in those early days, to forcing fires and to operating devices used in priestly incantations. By the time of Hero of Alexandria (150 B.C.) the water trompe, which compresses air by the fall of water in a tube, was in use for blowing forges. Hero described the pressure air pump or compressor for the first time. Otto Von Guericke made great improvements in both compressor and the vacuum pump about 1650. William Mann, in 1829, received a patent on compound compression of air, then called "stage pumping," which effected great economy and lighter compressor construction. Thilorier received a medal a year later from the French Academy for compressing gases to high pressures in stages.

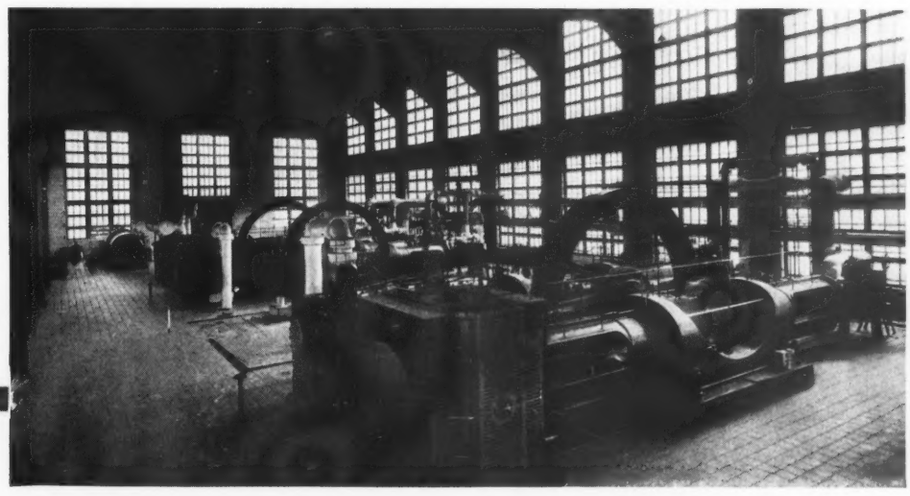
Not until 1872 was cooling of air during compression adopted, and then by Colladon in the St. Gothard tunnel. He sprayed water jets into the cylinder, the same method being used in single-stage machines. It was efficient enough, but led to other difficulties which soon caused it to be discarded for water-jacketed cylinders, although some wet-type compressors were still in use during the early years of this century.

The first compressor used on large-scale work in this country was the 4-cyl. horizontal built in 1866 for use in the Hoosac tunnel. Cylinders were single-acting, the pistons being driven by turbine wheel and air being admitted through poppet valves in the pistons. Water was injected through the inlet valves for cooling. It was later moved to marble quarries where a stream of water flowing over the cylinder was substituted for injection cooling.

Most modern compressors are double-acting, high-speed types using plate valves and unloading devices to permit economical operation with constant-speed synchronous motors.

Extremely high pressures are not new. Mekarski and Beaumont in Europe, and Judson, Hadley and Knight in this country attained them. Perkins reported compression to 17,640 lb. as early as 1826. Application had kept pace with development — as early as 1683 Papin proposed transmitting power for considerable distances by compressed air. His early ideas resulted in such famous plants as that serving the North Star mine near Grass Valley, Calif., where Edward Rix in 1890 transmitted air from a Pelton wheel-driven compressor many miles away to Corliss engines operating the mine's hoisting drums. Wood-fired heaters were used to heat the air before it entered the corliss engine to increase its power.

Compressed air drove machine drills patented by Colladon at the Mont Cenis tunnel in 1872. This was followed by compressed-air driving of locomotives in the St. Gothard tunnel and by mine use of compressed air in this country. Impelled by the inventive genius of Burleigh, Ingersoll, Sergeant, Rand, Clayton and others, compressors and compressed-air machinery for quarrying, mining, tunnelling and hundreds of other uses are common today.



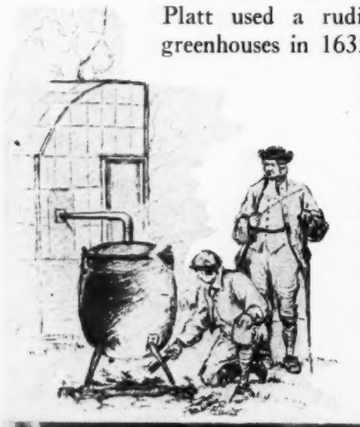
Trompe to modern horizontals — man's means for improving on the wind

LITTLE HISTORIES—1

HEATING and AIR CONDITIONING

ARTIFICIAL heating is probably as old as man's knowledge of fire. According to Elisha Harris, the chimney wasn't invented until about 1400 in Italy, but the fireplace was the only method of heating until stoves were used in Alsace in 1490. They came into general use several hundred years later. The cast-iron box stove was invented in 1752, sheet-iron stoves and base burners in the early nineteenth century. They're still in use, even though uncomfortable.

Franklin first attempted to build a hot-air furnace; the first practical one was in Worcester, Mass., in 1835. Romans had heated with hot water; then it was forgotten until Triedwell used it in Paris greenhouses in 1716. It found little favor here until the last quarter of the nineteenth century, when Edward Gurney developed a system using supply mains and branches to radiators. Sir Hugh Platt used a rudimentary steam heater for greenhouses in 1635. William Cook of Manchester, England, first proposed heating houses that way about 1750. In the United States, the first large building so heated was the Eastern Hotel, Boston. Pressures were 15 to 20 lb. Cast-iron radiators became common about 1880, supplanting pipe coils. Recent development of fin or extended-surface radiation has brought in blast heating and the unit heater.

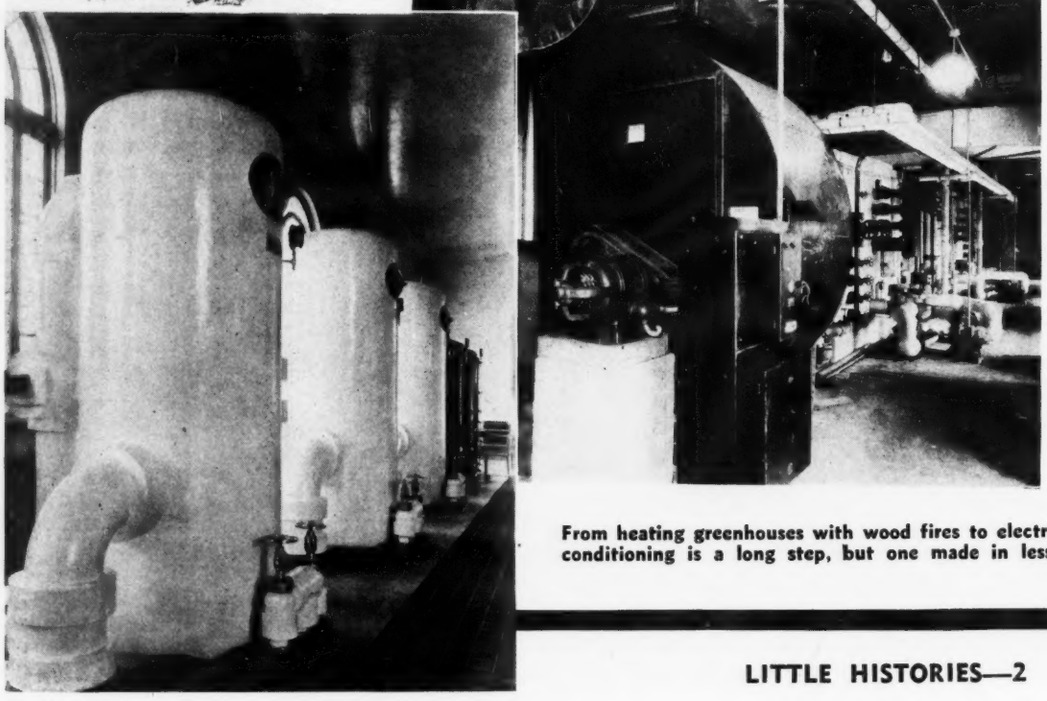


During the last fifteen years, many heating-plant control systems have been developed, including room thermostats controlling radiator valves, and "zone" heating-system subdivisions controlled by outdoor thermostat. Later ones followed development of the radiator orifice and the attendant uniform steam distribution—largely the work of J. A. Donnelly.

Ancient Egyptian rulers had slaves wave fans, early Persians projected air ducts from buildings, Romans left roof openings—all early attempts at ventilation or to regulate temperature. Sir Christopher Wren made an attempt to provide fresh air for the English Houses of Parliament in 1660.

Now we have air conditioning, involving regulation of temperature, humidity, cleanliness and movement. Prior to 1905, many water-atomizing devices were in use, notably in textile mills. Johnson, Cramer and Hodge, Carrier, Comfort and others developed automatic humidity controls, and the spray air washer was improved to produce complete saturation of air. Cooling of air passing through the washer provided a dehumidifier. But complete air conditioning was first applied in 1923 in theatres.

Much of our air conditioning is based on the study of psychrometry and psychrometric charts by W. H. Carrier, presented before the A.S.M.E. in 1911. Work at the A.S.H.V.E. research laboratory has also done much to further air conditioning.



From heating greenhouses with wood fires to electric heating and air conditioning is a long step, but one made in less than 400 years

LITTLE HISTORIES—2

REFRIGERATION

COOLING below surrounding temperatures is an ancient process. Cold natural spring water, cellars and caves served the ancients. In old India ice was made by exposing shallow, porous trays of water to the night air, heat thus being extracted by natural evaporation. In colder climates, men harvested winter ice and stored it in caves or buildings—as many still do. As early as 1607, learned men knew that cold is produced when certain salts are dissolved.

First experiments to produce refrigeration mechanically were made in 1755, when Dr. Cullen made a machine for evaporing water under a vacuum, and Lavoisier experimented with ether in France. Michael Faraday worked out the basis for the compression and absorption machine 68 years later, when he found that certain refrigerating fluids could be liquefied after being compressed to high pressure, then cooled. Eleven years later, Jacob Perkins produced a commercially successful mechanical refrigerating machine. He vaporized and expanded ether under reduced pressure, abstracting the vaporizing heat from water. The ether vapor, compressed into a water-cooled vessel, gave up its heat and condensed.

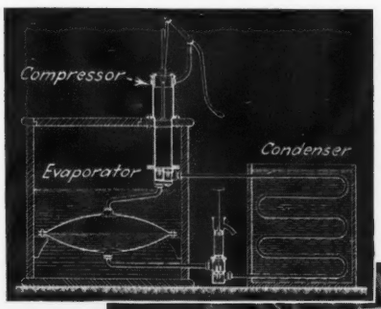
Dr. John Gorrie, American, in 1845 made the steps which led to the invention of the cold-air machine. This, the first machine successful in refrigerating meat in its long trip from Australia to Europe, was improved by Windhousen, Bell, Coleman, Haslam, Lightfoot, Hall, Gifford and others. By the end of the nineteenth century, compressed-air machines delivered air at 50 deg. below zero.

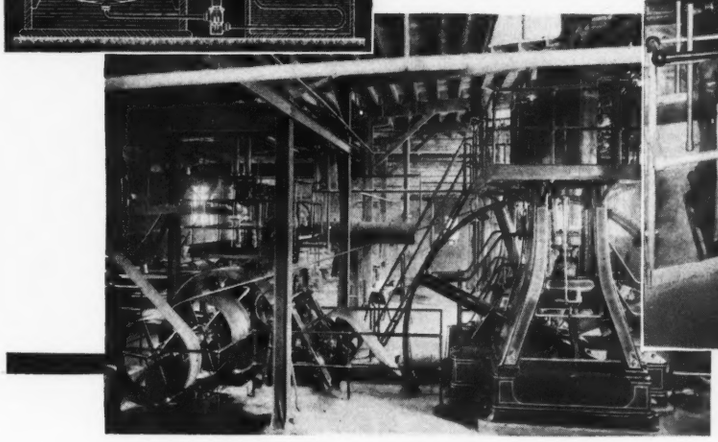
Between 1850 and 1885, Ferdinand Carre, of France, invented the absorption refrigeration process.

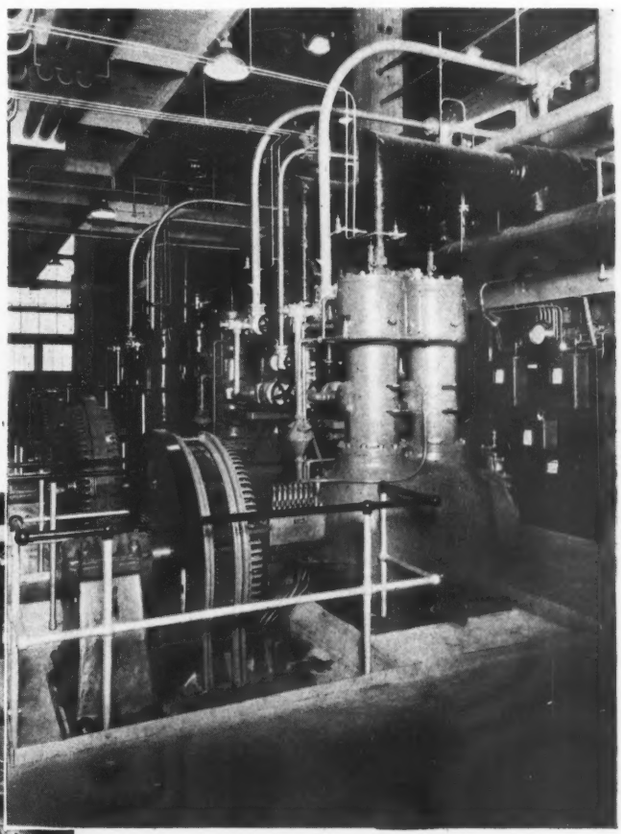
C. P. G. Linde of Germany and David Boyle of the United States introduced the first successful ammonia compression machines between 1873 and 1875. Until 1890 practical applications of refrigeration were quite limited, but 1890 brought an unprecedented natural ice shortage, and gave the impetus that started rapid development of mechanical refrigeration in this country. Since then, many improvements have been made in mechanical design, in efficiency of gas-condensing methods, in flooded or gravity-feed systems for evaporating surfaces. Thermal properties of many refrigerants have been determined, the commonest being ammonia, carbon dioxide, ethyl chloride, methyl chloride, and more recently, dichloro-difluoromethane.

Water has again come into popularity as a refrigerant in air-conditioning systems, where temperatures only as low as 40 to 50 deg. are required. Steam jets or centrifugal compressors produce high vacuum in which water is boiled. Units of 300-ton capacity are in regular use; a 600-ton unit is being installed.

Binary refrigeration cycles, booster compressors and compound compressors have been required by the development of quick-freezing processes.

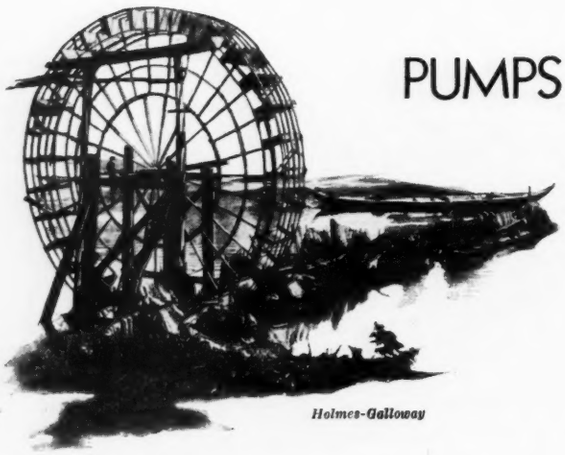






It is a far cry from Perkins' original refrigerating machine through the crude machines of yesteryear to the highly efficient ones of today

LITTLE HISTORIES—3



Holmes-Galloway

PUMPS

BEGINNINGS of the art of lifting water mechanically are lost in antiquity. Civilization learned early to irrigate land, and certainly one of the earliest uses of power-driven pumps was for that purpose. A common example is the Chinese Nora, a crude waterwheel carrying inclined sections of hollow bamboo on its outer surface which dipped below the surface of the water and carried a little to be spilled into a flume at the top as the wheel turned with the current.

To enumerate the types of pumps, their uses and the stories of their development, is not possible in this little history. It is only possible to hit high spots.

Until 25 years ago, plunger-type pumps were generally used. Since then, rotating types—centrifugal, cam, screw, gear, propeller—have been developed for almost every class of service.

Boiler-feed, hot-oil charging, oil-pipe line and other high-pressure services may now use centrifugal units. Several hundred thousand pounds of water per hour against pressures at high as 1,700 lb. per sq.in. can be handled by some boiler-feed centrifugal units. Some hot-oil charging pumps develop heads up to 7,500 ft., yet are housed in a single casing.

Low-head units will do things just as outstanding. Four storm-water pumps at Connors Creek Station in Detroit, for example, will each handle 325 million gallons a day against 27-ft. head.

Europe and her large pumped-storage hydro-electric developments has asked for, and gotten, pumps that require as high as 36,000 hp. to drive them. These are centrifugal units and may operate at heads of several hundred feet.

Now pump engineers are working to develop units that will either pump water or be driven by water. Two small installations have been made in Europe. A test unit in this country gave a turbine and pump efficiency of 68 per cent at equal speeds. Turbine efficiency rated 78 per cent at a speed 17 per cent below the equal efficiency speed, pump efficiency 78 per cent at a speed 12 per cent above. Best efficiency from such a unit requires pumping at a considerably higher speed than generating.

Propeller and screw-type pumps are finding an ever-widening field for low-head service. Many screw-type pumps lift drainage out of New Orleans backyards, some taking out 180,000 g.p.m. under 7-ft. head.

Propeller-type pumps lose efficiency rapidly with change in head or discharge, very much as do propeller-type waterwheels. But that has been fixed now—recent units have adjustable blades so that discharge may be held constant while head is varied over a wide range, or head may be held constant and discharge varied, without hurting efficiency much either way.

Pump history is being made rapidly these last few years. Self-priming pumps or devices to make pumps self-priming when they operate against suction lift are an example. Self-priming units act as hydraulic-type air pumps during priming, then automatically become regular rotating pumps when primed. Others use attached automatic vacuum pumps, still others have attached devices that make them act as hydraulic vacuum pumps until they're primed, after which they operate as standard centrifugal pumps.

From chain-and-pot to low-head pumps to handle 325 million gallons a day—a step of 2000 years

At top—An adaptation of the Nora

LITTLE HISTORIES—4

POWER TRANSMISSION

Holmes-Galloway

POWER TRANSMISSION is one of the oldest arts of civilization, for the ancient Egyptians, 4,000 years or more ago, used bow drills for fire making and drilling. The Egyptians also learned early to use flat belts or straps without a bow for heavy drilling.

After all, up until about 1700 there hadn't really been very much power to transmit. But when the waterwheel and the steam engine forced their way into medieval Europe they brought with them comparatively unlimited power—if only some way could be found to transmit it. The first prime movers were direct-connected, the waterwheel using the shaft, the engine the walking beam. This, however, limited the drive to the immediate vicinity of the prime mover.

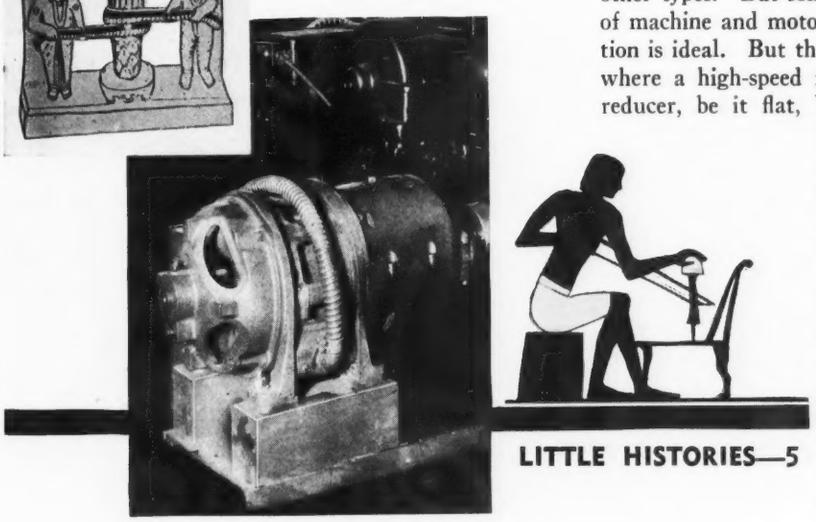
Yankees in New England tried to solve the problem first by furrowing their towns with canals from the water source to their waterwheels—but after all, you can't make every town a Venice. They next tried flumes and pipes, then long shafts, and finally rope drives. Shafts weren't very effective at distances over a hundred feet; rope drives began to eat up all the power in friction at about a mile.

Old type transmission equipment was not satisfactory. It was cumbersome, noisy, low in efficiency and exceedingly limited in range of application. But in the midst of all these difficulties came the encouraging news of the hydro-electric station in Appleton, Wis., and of Edison in New York, transmitting power electrically. Rapid development followed, for this provided power at almost any reasonable distance from the source and in almost any quantity.

Much of the old heavy mechanical power-transmission equipment became obsolete. A new field opened up for equipment to connect motors to machines. Flexible couplings, short-center flat belts, multiple V-belts, chains have replaced long, wide belts, and compact enclosed gear units have replaced the old-time clacking open gears.

Of course, as soon as direct drive became popular, many engineers assumed that it was the final solution for every difficulty, and that it would soon replace all other types. But somehow, it hasn't. Where speeds of machine and motor are comparable, direct connection is ideal. But there are many power applications where a high-speed motor and some form of speed reducer, be it flat, V-belt, gear or chain, is much more satisfactory. And there are many more places where modern group drive is coming again into its own—for the one good reason that it costs less to install and to operate. Where variable speeds are needed, a mechanical or hydraulic variable-speed unit and a constant-speed motor in combination often provide a power unit that is more economical than an adjustable- or a variable-speed motor.

Power use demands principally economic transmission. One man, two men, one camel—now several horsepower in small space — whatever the power, there must be a transmission



LITTLE HISTORIES—5

LITTLE HISTORIES—6

Otis demonstrates the first safe elevator

ELEVATORS

ONE hundred years after Archimedes—still two centuries before Christ—the first freight elevators were in use. No one thought of lifting men—not until eight hundred years later and the development of workable mine hoists.

"Elevators" first appeared in America with Henry Waterman's invention of 1850. Two years later, Elisha Graves Otis, Vermonter transplanted to Yonkers, N. Y., devised a hoist running in guides and with a safety device that clamped the car to the guides if the hoist rope broke.

Even after this convincing demonstration, it took New Yorkers three or four years to get used to the idea. Finally in 1857 E. V. Haughtwout installed one. Two years later came the famous vertical-screw railway in the old Fifth Avenue Hotel. 1866 saw the stationary-cylinder steam engine applied to elevators. In elevator machines, 1865 brought the screw-belt machines, 1869 the iron-frame spur-geared belt machine.

The first vertical geared hydraulic elevator, installed in the Stephens Hotel, New York, in 1872, introduced the high-speed elevator and the "sky-scraper" (meaning anything over four or five stories). As higher water pressures became available, hydraulic elevators increased in speed until 600 f.p.m. was possible. Developments now were coming thick and fast. 1878 brought the safety elevator governor, 1880 the first electric elevator (installed by Siemens & Halske at Mannheim, Germany), 1887 America's first electric elevator (designed and installed by William Baxter, Jr., in Baltimore, but unsuccessful). Two successful ones were installed by Otis in December, 1889, in the building of A. T. Demarest in New York. These were direct-connected worm-gear, drum-type units with mechanical control.

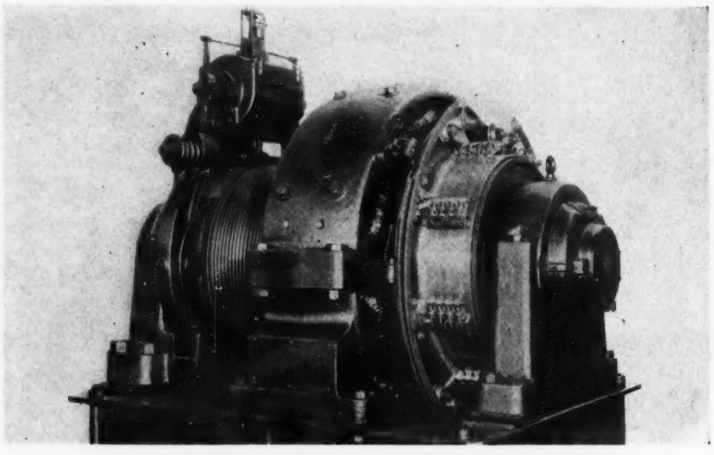
1902 saw the installation in the Majestic Theatre Building, Chicago, of the first one-to-one gearless traction elevator machine, destined to answer the need for high-speed elevators in tall buildings. With improvements in control, this type was to provide vertical transportation in the Empire State and similar buildings.

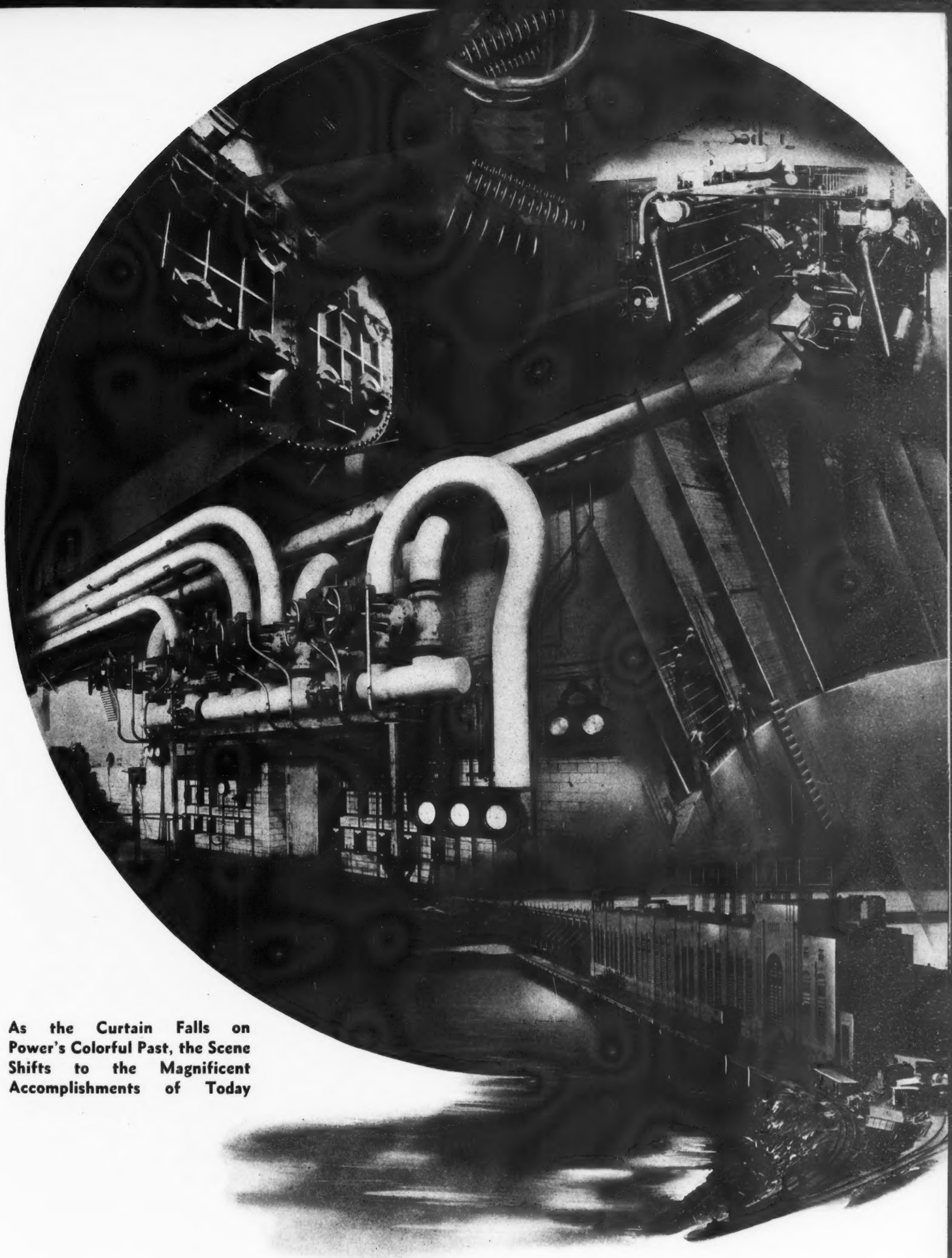
Automatic signal control came in 1924 with the installation in the Standard Oil Building, New York City. Most installations since then in tall buildings use automatic control, for it would obviously be impossible to serve our present-day tall buildings effectively with the manual switch operators of just a short ten years ago.

Fairly early in the electric elevator industry, Ward Leonard developed the variable-voltage control. This system requires a generator for each elevator motor, and adjusts generator field current for control. At first it wasn't very successful, but with modern refinements it has made possible high-speed automatic elevators operating up to 1,200 f.p.m. or higher, such as those used in the main building in Rockefeller Center and in the Empire State Building, New York.

Two other advances in elevator design should be mentioned, possibly because both seemed so fantastic but a few years ago. The first is the double-deck passenger car developed by Otis and installed in the Cities Service Building, New York. Each car is two separate compartments, one on top of the other, in a single frame and operated by a single double-wrap traction machine. Westinghouse produced the other, two independent elevator cars in one hoistway, the first installation being in the company's office building in East Pittsburgh. This system is based on the patents of Frank Sprague.

Eight-pole unit for double cars in Cities Service Building





As the Curtain Falls on Power's Colorful Past, the Scene Shifts to the Magnificent Accomplishments of Today

PLANTS TYPICAL OF 1934

Summarized by
R. B. PURDY
Associate Editor

BUZZARD POINT

• BUZZARD POINT, steam-electric central station at Buzzard Point on Potomac River, Wash., D. C. Owner: Potomac Electric Power Co. Engineers: Stone & Webster Engineering Corp. Construction started in 1932. First 35,000-kw. unit in operation, fall of 1933, only new central station to start operation during the year.

Cycle

A fair number of stations operate at 1,400-lb. steam pressure and 750-deg. F. temperature, with necessary reheating of steam after part expansion. Buzzard Point exemplifies newer trend; elimination of reheating complications by use of the highest practicable steam temperature and with it as high a steam pressure as can be used without producing excessive moisture at exhaust. For Buzzard Point, this formula worked out to give 835 deg. F., and 670 lb. steam with regenerative heating (three bleed points). Station heat consumption of 12,290 B.t.u. is being obtained. Boiler efficiency averages 86.4 per cent.

Boiler Units

Station design calls for one boiler (375,000 lb. per hr. continuous steam capacity), serving each 35,000-kw. turbine. However, two boilers went in with this first turbine providing a spare. They are single, cross-drum, straight-tube, single-pass units. The 72-in. diameter cross-drum is unusually high above the inclined boiler tubes. There are only five rows of boiler tubes. Staggered refractory-covered tubes across the furnace throat provide a slag screen.

Steam-washing arrangement is an example of the new trend. Before leaving boiler drum, steam passes first through a separator, then through a washer flushed with feed water, then through a second separator. This "wringing and rinsing" reduces the final moisture to ¼ per cent and carryover of solids to one part per million (estimated).

Economizer and convection-type superheater are in the setting between the boiler tubes and drums, and are separated by a water-cooled, vertical, central baffle. A sloping section of baffle directs exit flue gas evenly into air preheater.

Superheater and Deheater

Convection superheater on upflow side of vertical baffle is divided into sections *A* and *B*. Parallel flow of steam at high velocity avoids excessive tube-metal temperature. Steam from boiler drum is heated in *A* to 760 deg. It then passes through an external deheater and back through *B*, emerging at 835 deg. F., which is kept constant by automatically controlling the fraction of steam bypassed around deheater. Hairpin tubes in deheater are immersed in water from boiler drum and cool the steam to 660 deg. Steam made in water space of the deheater passes to boiler drum.

Furnace

Furnace is entirely water-cooled, chiefly by stub tubes covered with plastic refractory. Above slag screen, water-wall tubes are covered with bare cast-iron blocks. Ash collects in slag-tap furnace bottom, thence is discharged to be disintegrated and carried away to an elevated storage bunker by sluicing water. Furnace bottom water cooled, tubes being protected with smooth cast-iron block.

Firing

Pulverized coal, unit system, is served by two (8 tons per hour) pulverizers per boiler, each supplying 3 multiple inter-tube burners. Burners, 14 ft. above slag, fire downward to increase ash deposit and insure fluid slag. Furnace combustion heat release is 38,500 B.t.u. per cu.ft. at maximum output.

Coal Handling

Coal received by rail is delivered to station bunker by belt conveyor. Drag scraper stacks and reclaims coal from storage.

Air Preheater

Two-pass tubular preheater provides combustion air at 425 deg. at full load. Gas flows inside tubes. Varying amounts of heated air are recirculated from the forced-draft duct to prevent condensation and consequent corrosion. Vertical traveling-type soot blowers clean preheater tubes.

Fly-Ash Precipitation

Importance of fly-ash elimination in Washington led to installation of electrostatic precipitators three

sections deep in direction of gas flow. Special provisions made to secure uniform distribution of gas entering precipitator. Fly-ash removed from precipitators by vacuum air transport system. Dry ash discharged from storage by star feeder and rotary dustless unloader in which a controlled amount of water is mixed with it so ash can be taken out and transported by truck.

Turbine

First turbine 35,000 kw. (ample space for future 50,000-kw. units). Unit has 18 stages, runs 1,800 r.p.m. Voltage, 13,800. Direct exciter and pilot exciter on main shaft extension. Steam bled for feed heating from 7th, 11th and 14th stages. There is no wall between boiler and turbine room. Control of boilers and turbines is centralized in aisle between boiler and turbine rooms.

Heaters

Three-stage bleeding for feed heating. Open bleeder heaters used for low cost and high efficiency. Water "raining" through perforated trays contacts bled steam. Desuperheating heater installed in extraction line from 7th-stage heater, which will raise temperature of feed water about 6 deg. above saturation temperature corresponding to 7th-stage pressure. Final feed water temperature is 364 deg.

Fire Protection

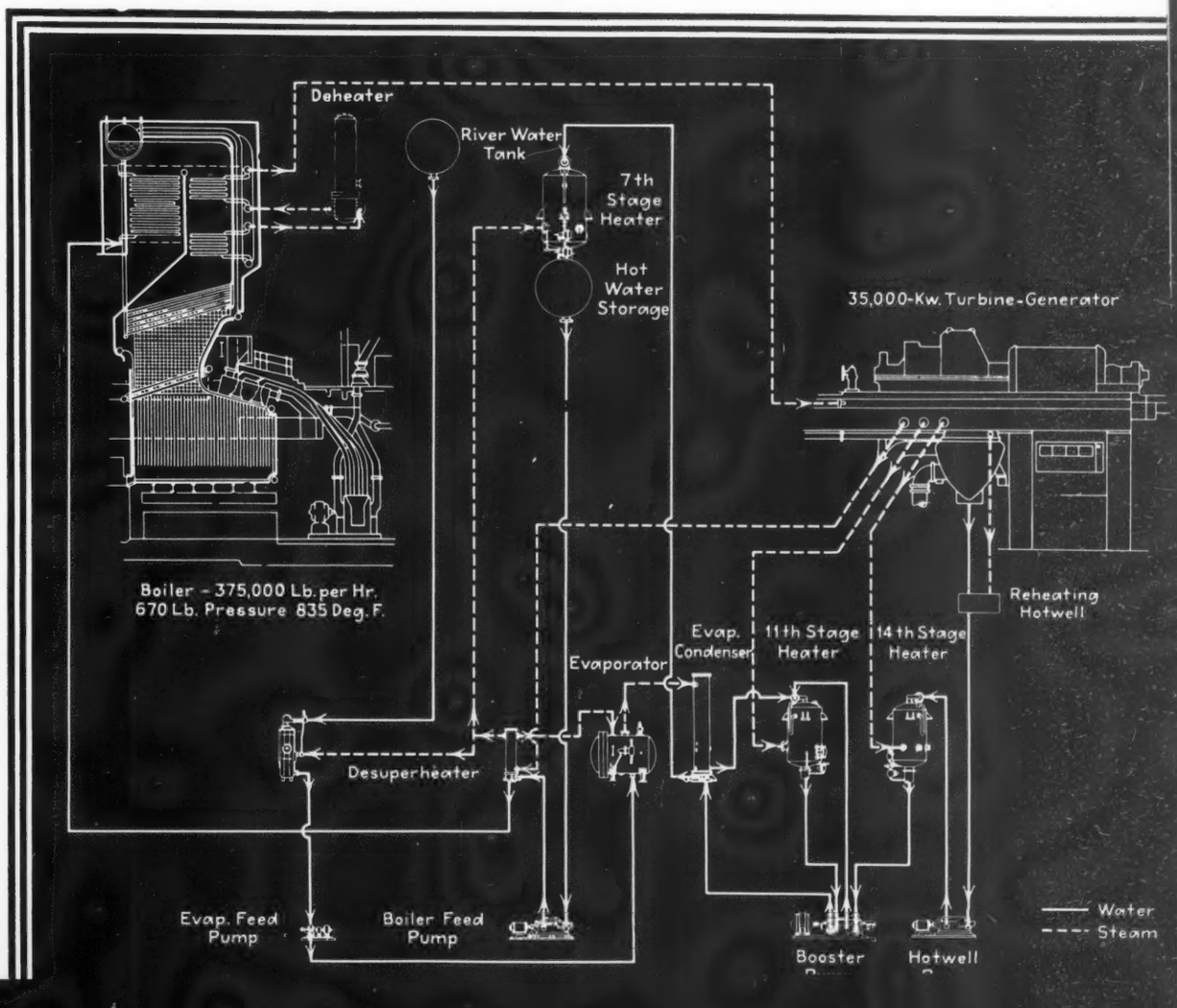
Reflecting lessons of several disastrous turbine-lubricating-oil fires, special precautions were taken at Buzzard Point. All pressure piping to turbine hydraulic gear and bearings, also to three non-return valves in steam extraction line, is run inside of drain lines returning to oil reservoir. Prevents pressure oil splashing hot steam pipes. Oil pump geared from turbine shaft, oil coolers, strainers, oil reservoir, oil purifier, and pump part of relay unit are in fireproof room immediately under turbine. This room is protected with CO_2 gas bottles that discharge automatically in case of fire. A separate fireproof room for oil storage, filtering and conditioning is protected by steam smothering nozzles.

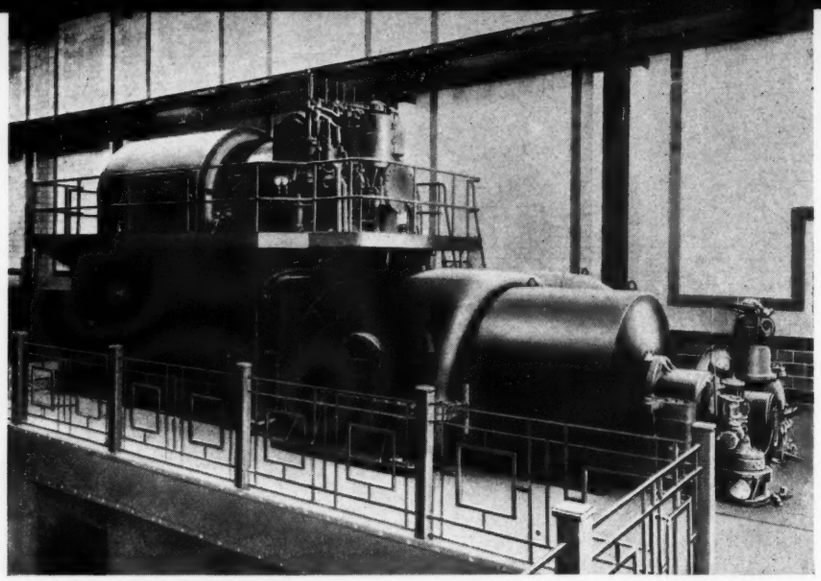
Pipe Insulation

High-temperature flange covers are replaceable blankets of rock wool 4 in. thick shaped to curvature of flange and made up in asbestos cloth with brass wire insertion. Aluminum foil sheet attached to inside of this blanket radiates heat back to flanges and studs when lines are being heated from cold. This tends to prevent excessive stress in studs.

Auxiliaries

All auxiliaries motor driven except one turbine-driven boiler feed pump and one lubricating-oil pump. Forced and induced-draft fans (two per boiler) are driven through hydraulic couplings to permit wide range of speed control. Two forced-draft fans are on a single shaft and driven by one 900-r.p.m. motor. Provision is made for a second motor at other end of shaft to drive at 1,200 r.p.m. Induced-draft fan similarly arranged.





SOUTH AMBOY

• SOUTH AMBOY, steam-electric central station at South Amboy, N. J., on Raritan Bay. Owned by Jersey Central Power & Light Co. Engineers: Management & Engineering Corp. First 25,000-kw. unit in operation in 1930. It is one of four central stations to start with an initial pressure of 1,400 lb., all other high-pressure installations being additions to lower-pressure plants. Present capacity 50,000 kw.

Cycle

With 1,400-lb. pressure, reheating is necessary after partial expansion to obtain safe percentage of moisture in exhaust. At South Amboy both steam and gas reheaters raise steam temperature between high- and low-pressure elements of turbine to 750 deg.—the limit of steam temperature at that time. Five stages of bleed heating are employed, using direct-contact jet-type heaters. Station heat rate of 12,331 B.t.u. is being obtained. Boiler efficiency averages 84 per cent.

Boiler Units

Three boilers (275,000 lb. per hr. maximum capacity) serve two turbines. They are single-pass, cross-drum type with relatively little heating surface in tube bank. Steam washers similar to those described in article on Buzzard Point (page 318) have been installed in boiler drum to decrease carryover of solids which has caused trouble in many high-pressure plants.

Superheater and Desuperheater

Return-bend convection superheater is above boiler tubes and is designed to raise steam temperature to 750 deg. at normal output. From superheater, steam passes through submerged-type desuperheater provided with thermostatic control that varies water level in desuperheater to maintain constant temperature of steam to main units. Desuperheater fed with water from boiler drum, which also receives any steam that may be generated in desuperheater.

Economizer, Gas Reheater and Air Preheater

Flue gas passes downward through gas reheater and economizer, and upward through tube-type air preheater. Gas reheater on each boiler receives steam from live-steam reheater directly above drum of each boiler. Gas heater consists of three banks of 2-in. diameter tubes having an effective heating surface of 13,000 sq.ft. Steam is reheated to 750 deg. and passes to low-pressure cylinder of turbine. Steel-tube return-bend economizer directly below reheater heats feed water to about 545 deg. at full load. Air preheater is directly in back of economizer and reheater, flue gas passing upward through preheater tubes, which are 40 ft. long. Air is preheated to about 465 deg.

Furnace and Firing

Slag-type furnaces are completely cooled by water tubes covered with cast-iron blocks. Furnace volume is 12,900 cu.ft., providing for a heat release of 24,000 B.t.u. per cu.ft. at normal load.

Five air-swept ball-type pulverizers per boiler supply pulverized coal. Each mill, of 2.5-ton per hr. capacity, feeds its corresponding burner. About half of preheated primary air passes through mill, giving a low velocity. Remaining primary air is drawn in by 7,000-c.f.m. exhauster at outlet of each mill, which delivers pulverized coal to burner at high velocity. Burners on two boilers are Calumet type, those on other boilers obtain turbulence by introducing preheated air in puffs at burner nozzle.

Combustion controlled by semi-manual system which premeasures both coal and air to each burner in pounds per hour, making it possible accurately to proportion one to other as desired. Storage of crushed coal in 125-ft. high concrete silos outside of plant

eliminates inside bunkers and greatly reduced building steel work.

Turbines

High-pressure permitted an entirely new turbine arrangement of compounding wherein high-pressure unit and its 5,770-kw. generator is placed on top of low-pressure 19,230-kw. generator giving a steeple-compound unit of 25,000-kw. capacity. The two units at South Amboy were the first of this type. A 110,000-kw. unit in the Ford Motor Company's Dearborn plant is largest of this type.

Steam is supplied at throttle at 1,250-lb. pressure and 750 deg. It exhausts from high-pressure cylinder to steam reheater and gas reheater and enters low-pressure element reheated to 750 deg. High-pressure element operates at 3,600 r.p.m., low-pressure at 1,800 r.p.m. Steam for feed heating is bled from 5th stage and exhaust of high-pressure cylinder and from 1st, 7th and 12th stages of low-pressure element. Low-pressure turbines exhaust to single-pass condenser with divided water boxes so that half of each condenser can be cleaned with other half in service. Valves are in water-box partitions.

Feed-Water Heaters

Condensate is heated in four jet-type direct-contact heaters and one open deaerating heater. At full load condensate leaves last heater at about 520 deg. and 812-lb. pressure. It is pumped through heaters by hotwell and booster pumps. Hotwell pump has three stages. Each stage discharges through a heater from which condensate returns to pump. Booster pump is similar, but has only two stages. Make-up water supplied by single-effect evaporator which takes steam from first extraction point of low-pressure turbine element.

Steam Reheaters

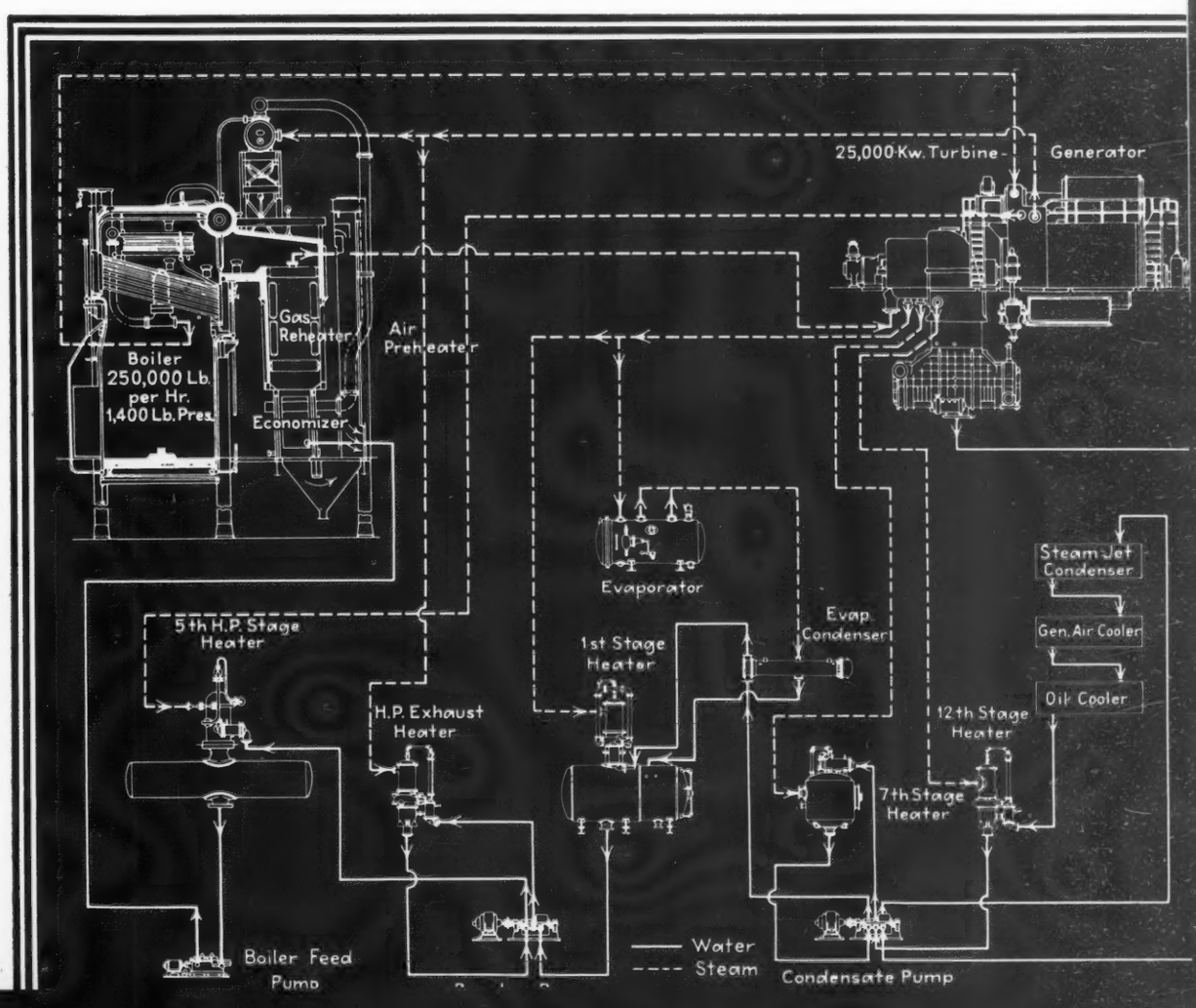
Steam reheaters consist of 45-in. diameter, 26-ft.-long, inclined drums directly above each boiler drum. Heating steam, taken from boiler drum at 1,400 lb. pressure, passes through tubes in reheater and condensate returns directly to boiler drum by gravity. Thermostatic control governs flow of high-pressure heating steam to reheater, so varying the temperature rise in steam reheater to maintain constant temperature of 750 deg. at gas reheater exit.

Fans and Stack

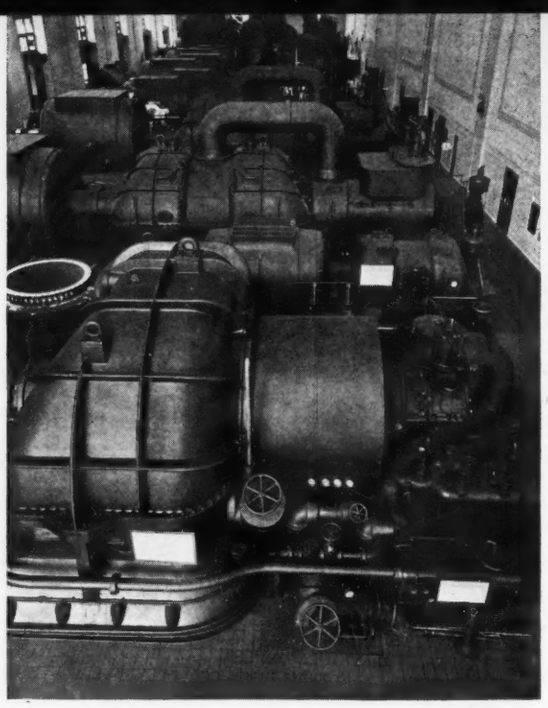
Two forced-draft fans per boiler, each of 40,000-c.f.m. capacity, supply preheated air to pulverizers and coal burners. Two induced-draft fans incorporated in base of venturi-type stack provided for each boiler. Stacks are 4 ft. 10 in. in diameter at throat and 10 ft. in diameter at top.

Electrical

Generators feed at 13,200 volts to a double-bus system. Transformers are wound to give high-side voltages of 33 kv., 66 kv. and 132 kv. in order to connect to various transmission lines. Switching is done on both high- and low-tension sides. Power for auxiliaries is taken from main bus through transformers that step voltage down to 440. All auxiliaries, except oil pump and steam jets, motor driven.



HUDSON AVENUE



• HUDSON AVENUE steam-electric central station in Brooklyn, New York City, on the East River, owned and engineered by Brooklyn Edison Co. First 50,000-kw. unit placed in operation 1924, and two completing units of 160,000 kw. each placed in operation in 1932, making this station largest steam power plant in world, total capacity 770,000 kw. This capacity was installed in building originally intended for 400,000 kw. in eight 50,000-kw. turbines. Power concentration at this plant is 7.4 kw. per sq.ft. and 64 kw. per 1,000 cu.ft. of building.

First three units of 50,000 kw. operate at 275 lb. pressure and will not be here discussed. Latest units operate at 400 lb. pressure and 700 deg. High- and low-pressure sections of station are tied together by reducing valves and desuperheater. 400-lb. section of station contains five units with total capacity of 620,000 kw. It operates on regenerative cycle, with economizers in all but one unit, which has air preheaters. Heat rate of high-pressure part of plant averages 13,620 B.t.u. per kw.-hr. Boiler efficiency averages 85.9 per cent.

Boiler Units

Boiler house is arranged so that a row of four boilers serves a turbine unit, there being three rows in low-pressure section, and five rows in high-pressure section. Except for last two rows, all boilers are three-pass, cross-drum, inclined-tube type. Eight boilers in the last two rows are three-drum, bent-tube units. Several departures from standard practice were made in boiler accessories, among them being a decrease of over 50 per cent in number of blowoff valves used and elimination of water columns, gage glasses being attached directly to drum heads. Capacity of 400-lb. boilers in first row is 290,000 lb. of steam per hour, boilers in second and third rows are each capable of delivering 350,000 lb. per hr. and boilers in last two rows have a maximum capacity of 530,000 lb. each.

Superheaters

Superheaters for first three rows of high-pressure boilers are of interdeck type and superheat to 700 deg. Superheaters for last eight boilers are designed for 750 deg. and tube elements are disposed within first bank of boiler tubes. They are held in place by alloy clamps, but supported from headers above front boiler drums.

Economizer and Air Preheater

First row of high-pressure boilers were equipped with plate-type air preheaters which provide air at about 350 deg. to underfeed stokers. Other boiler units have return-bend economizers and no air preheaters. Economizers for last eight boilers have vertical fins lengthwise of tubes, and no soot blowers were installed, as they are washed with water when unit is out of service.

Firing

All boilers are fired with underfeed stokers equipped with clinker grinders. Stokers serving last two rows of boilers are 69 tuyeres long, having 694 sq.ft. of projected grate area. At full load 82 lb. of coal per sq.ft. of grate area per hour is burned, with a heat release of 57,000 B.t.u. per cu.ft. of furnace volume. These stokers are driven by variable-speed hydraulic transmission. One of these units has been equipped with air-volume control and remaining seven are being equipped. Furnaces are water cooled with bare tubes having 1-in. fins welded on both sides. First row of 400-lb. boilers has plain bare-tube water walls and next two rows of boilers have water walls protected with refractory-faced cast-iron blocks. Settings are insulated and steel cased. Except for first row, which has wound-rotor drive, vane-controlled forced and induced-draft fans driven by squirrel-cage motors are installed with all high-pressure units.

Coal and Ash Handling

All coal is received in barges and unloaded by any of three coal-hoist towers. No outside coal storage is provided, consequently station bunkers are larger than usual. Coal is distributed to bunkers by electrically operated 5-ton cars. On its way to bunkers each car of coal is weighed. Travelling weigh lorries in each aisle distribute coal to stoker hoppers, making it possible to keep an accurate record of each boiler's performance. Ashes are removed by hydraulic sluice to a concrete settling basin on wharf, from which they are loaded to scow by clamshell bucket.

Equipment is installed on all boilers to catch any

cinder carried up with gas. Dry-type cinder catchers were installed on first two rows of high-pressure boilers. A more efficient wet type was developed and installed for later boilers. They consist of triangular plates arranged vertically over a tank of water. On inlet side alternate edges of plates are bolted together and on outlet side opposite alternate edges are bolted so that flue gas passes down through alternate spaces between parallel plates, impinges against water, turns and flows up between plates. Cinders thrown out by abrupt change in direction settle to bottom of basin, although some collect on water surface. Skimming nozzles keep surface of water free of light cinders, which are discharged over a weir. Deposit in the basin is periodically sluiced out by high-pressure jets. Triangular plates are enameled to resist combined action of cinders, salt water and relatively high temperatures. Basins are cast iron, brick-lined at water line.

Turbines

First turbine in 400-lb. section is an 80,000-kw. cross-compound unit. It was followed by two 110,000-kw. cross-compound turbine-generators. The two last units are each of 160,000-kw. capacity tandem-compound units, largest of this type in operation (a slightly larger unit is under construction for Richmond Station of Philadelphia Electric Company.) Means are provided for collecting and removing moisture formed in expanding steam. Single winding generators are rated at 200,000 kva. and 80-per cent power factor. Generator ventilation provided by four motor-operated fans on top of the generator. Generator air coolers are on turbine-room floor on both sides of generator.

The 80,000-kw. unit bleeds from 4 stages for feed-water heating in closed-type heaters. As economizers are installed with last four units, turbines are arranged for bleeding from only two stages for feed heating.

Development in connection with last unit is installation of set of experimental supervisory control instruments for determining vibration of turbine at four points, expansion and eccentricity of high-pressure turbine shaft and unusual sounds in both high- and low-pressure cylinders.

Condensers and Auxiliaries

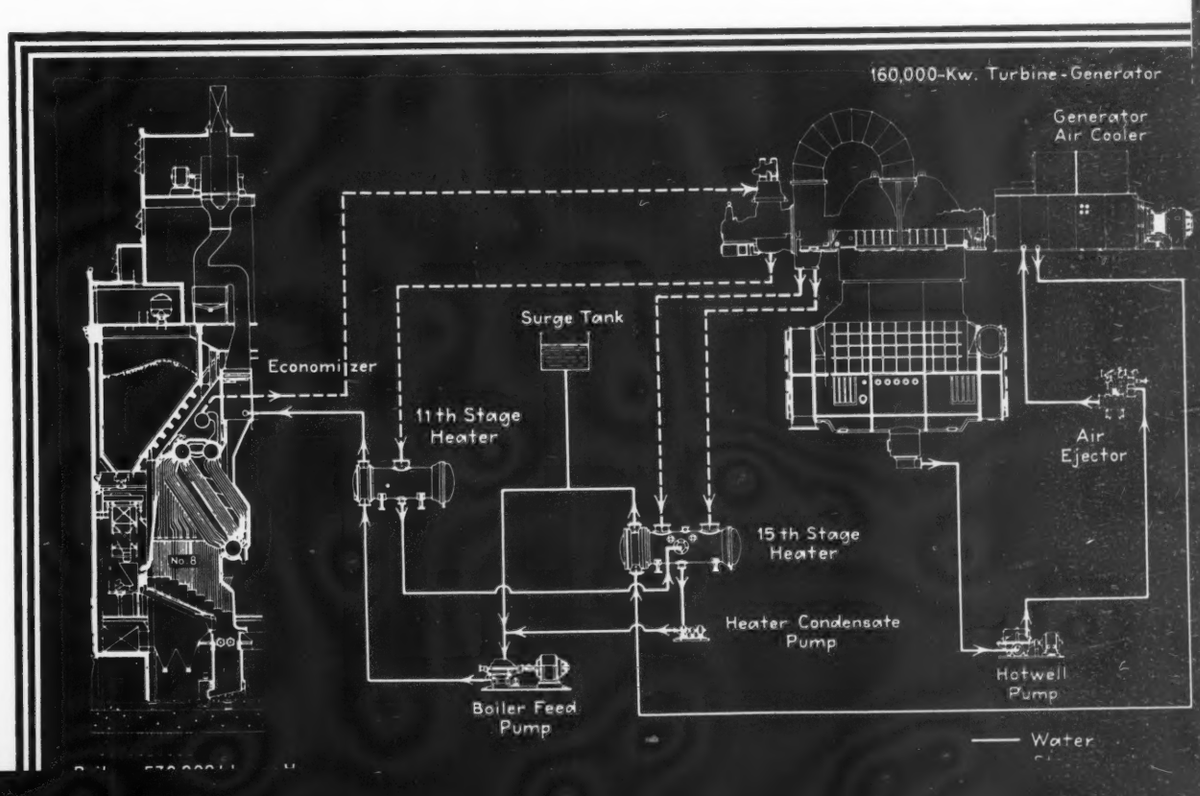
Condensers used with two 160,000-kw. turbines, though of different manufacture, each has 101,000 sq.ft. of cooling surface. They are largest single-pass condensers in operation. Each condenser is supplied with circulating water by two pumps, each of 73,000 g.p.m. capacity. Steam-jet air ejectors are used on all condensers and Le Blanc air pumps on all but last two. All auxiliaries are motor driven, except four steam-driven pumps out of 32 boiler-feed pumps. There are only two house turbines, these are in low-pressure section of plant. All auxiliary motors over 50 hp. are designed for 2,300 volts.

Combustion Control

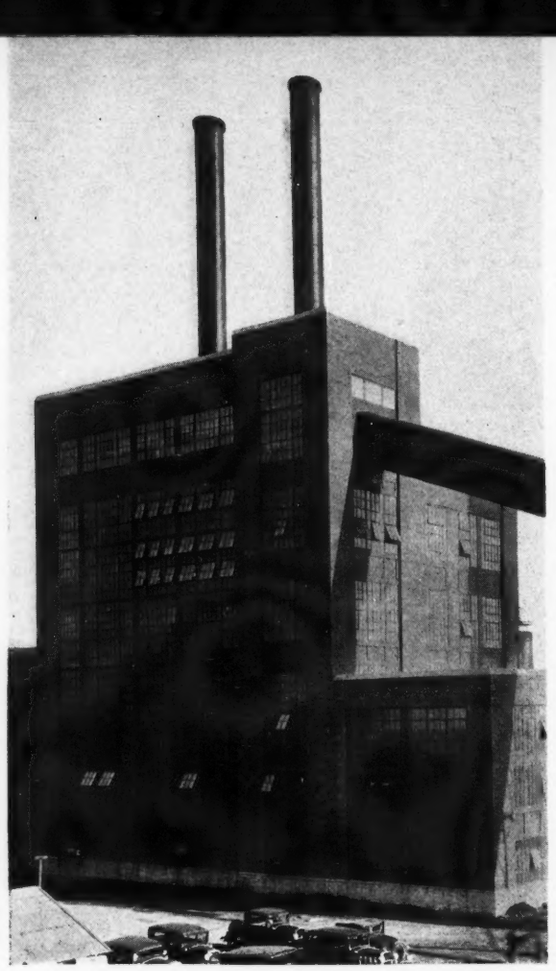
Automatic combustion control is provided for both low- and high-pressure sections of plant. Control elements are regulated by air pressure and oil under pressure is used as motive force. In high-pressure section each row of boilers has its own master controller. Steam-pressure-actuated supermasters translate changes of steam pressure into changes of air loading pressure which are distributed to various section masters. For last two units air-duct pressure and suction at induced-draft fans is controlled by varying position of vanes at fan inlets.

Electrical

Current is generated at 13,800 volts, except last two units which generate at 16,500 volts, and is stepped up to station bus at 27,600 volts. Station ring bus is in switch house building separate from steam station and arranged for vertical phase separation. Main switchboards, as well as auxiliary control panels, are in this building.



FORSTMANN WOOLEN



• FORSTMANN WOOLEN COMPANY, industrial steam power plant at Garfield, N. J., on Passaic River. Design and construction supervised by C. H. Schlachter and F. L. Bradley, construction department, Forstmann Woolen Co. In operation July, 1933. Present generating capacity 4,300 kw. Replaces old boiler house and engine room now used as machine shop and manufacturing building.

Cycle

Steam generated at 450 lb. pressure used in turbine-generators and auxiliaries. Mill supplied with steam at 100 lb. pressure from exhaust of one turbine or from reducing valve and with 20-lb. bled steam and auxiliary exhaust. Condensate from mill returns at 120 to 180 deg., makeup water softened with zeolite. Generating units all equipped with condensers, but smaller unit exhaust at 100 lb. or 20 lb. pressure except when carrying light Sunday and night loads.

Building

Power plant building is simple, being built of common brick and steel. Turbine room and boiler room interiors finished with selected common brick laid to avoid ledges and dirt-collecting corners.

Boiler room on north side of turbine room, partition wall between being glass. Extension to west end of boiler room houses office, laboratory, and water-treating plant which serves both power plant and process requirements of mill. Electrical bay on south side of turbine room. Switchboard panels on main operating floor.

Boilers

Two bent-tube boilers designed for 450 lb. pressure installed. Each capable of delivering 80,000 lb. of steam per hour superheated to 610 deg. F. Each boiler has one dry drum, three wet drums, heating surface of 6,520 sq.ft. Drums fusion welded. Single-pass superheater above second row of boiler tubes discharges to header on top of boiler. Inlet ends of superheater tubes rolled into dry drum.

Furnace and Firing

Pulverized-coal furnaces cooled with bare water walls except for portion of wall near burners, which is refractory covered to improve ignition. Water walls fed from lower boiler drum to headers at bottom of side, front and rear walls. Furnace is hopper bottomed and has 4,500-cu.ft. volume. Side and rear walls 2 in. ship-lap refractory tile backed with insulation. Front wall solid refractory backed with insulation. Entire setting steel encased.

Coal to each boiler fired through one flare-type burner provided with oil burner for ignition and use during low loads.

Coal Handling

Coal delivered by rail to track hopper, from which apron conveyor feeds 90-ton-per-hr. coal crusher. Inclined belt conveyor delivers crushed coal to 250-ton overhead bunker or to 2,500-ton yard storage served by drag scraper. Bunkers discharge through automatic weigh scales to mill feeders on boiler-operating floor and from feeders to pulverizers on basement floor. Each of two 5,000-lb.-per-hr. pulverizers is connected to one boiler. Third mill arranged so it can serve either boiler. One mill will carry its boiler to about two-thirds' maximum capacity; for higher loads third mill must also be operated. Hot primary air from forced-draft system dries coal in pulverizer. Ashes collected in furnace bottom are removed by sluicing system that also disposes of soot removed from stack, last boiler pass and scrubbers. Sluicing system discharges to settling basin from which ash is pumped to overhead dewatering storage tank outside plant.

Air Preheaters

Vertical, single-pass, tubular air preheaters, having 6,550 sq.ft. of heating surface are in back of each boiler. Flue gas enters preheaters at bottom and flows vertically outside of tubes to fan floor above boilers where it passes first through scrubbers and then to turbine-driven induced-draft fans, one per boiler. Gas scrubbers consist of series of baffle

plates over which continuous film of water flows. Ebony-impregnated Transite pipe, coated inside with asphalt, drains scrubber. Turbine-driven forced-draft fans, one per boiler on same floor, discharge through tubes of air preheaters.

Combustion Control

Boilers provided with automatic electrical combustion control. This system regulates forced- and induced-draft fan speeds and dampers and controls coal feeders. Control equipment is on master panel at one end of operating aisle and on each individual boiler gage board.

Feed-Water System

Make-up water, which may run as high as 75 per cent, is obtained from Passaic Valley Water Commission system and treated in two gravity-type zeolite softeners. Average rate of water treated by each softener is about 9,000 gal. per hr. Treated water is stored in two steel tanks, each having 13,500-gal. capacity. Condensate and softened makeup first pass through continuous blowdown heat exchanger, then are pumped to deaerating heater by two 300-g.p.m. pumps. Deaerator will heat and deaerate 150,000 lb. of water per hr. to an outlet temperature of 258 deg. It is supplied with steam at 20-lb. pressure and has a storage capacity of 3,000 gal. Mill returns and powerhouse heating returns also go through deaerator. Boiler feed pumps take their suction from deaerator. Normally one of three feed pumps, two of which are 200-g.p.m. turbine-driven and one 300-g.p.m. motor-driven, feeds boilers through water-level regulators. Pressure drop across feed-water regulators actuates either valve control of turbine drives or regulator controlling chronometer valve in discharge from motor-driven feed pump.

Turbine-Generators

Turbine room contains one new 2,000-kw. condensing unit, one old 2,000-kw. condensing unit taken from old plant and reconditioned and 300-kw. non-condensing unit. Both 2,000-kw. units are arranged for automatic constant-pressure bleeding at 20 lb. pressure for process and heating. Old unit rebladed for operation at 225 lb. pressure supplied through reducing valve and is used mainly as spare. Oil-operated non-return valves in extraction lines from each unit prevent steam flowing back into turbine and causing overspeeding. This valve trips closed when machines shut down.

The 300-kw. turbine normally operates against 100-lb. back-pressure supplying high-pressure requirements of mill. It can also exhaust at 20-lb. back-pressure or to condenser. On weekends, when mill is shut down and load is light, this unit is operated exhausting to 20-lb. pressure for heating in winter and to condenser in summer. Condensers for 2,000-kw. turbines are two-pass, each having about 1,290 sq.ft. of surface. Tubes are rolled into each tube sheet, expansion being taken care of by expansion joints in condenser shells. Air removed by two-stage steam jets. Condenser for 300-kw. unit is of Navy type with internal air cooler. Two condensate pumps provided for each condenser and two circulating water pumps for entire plant.

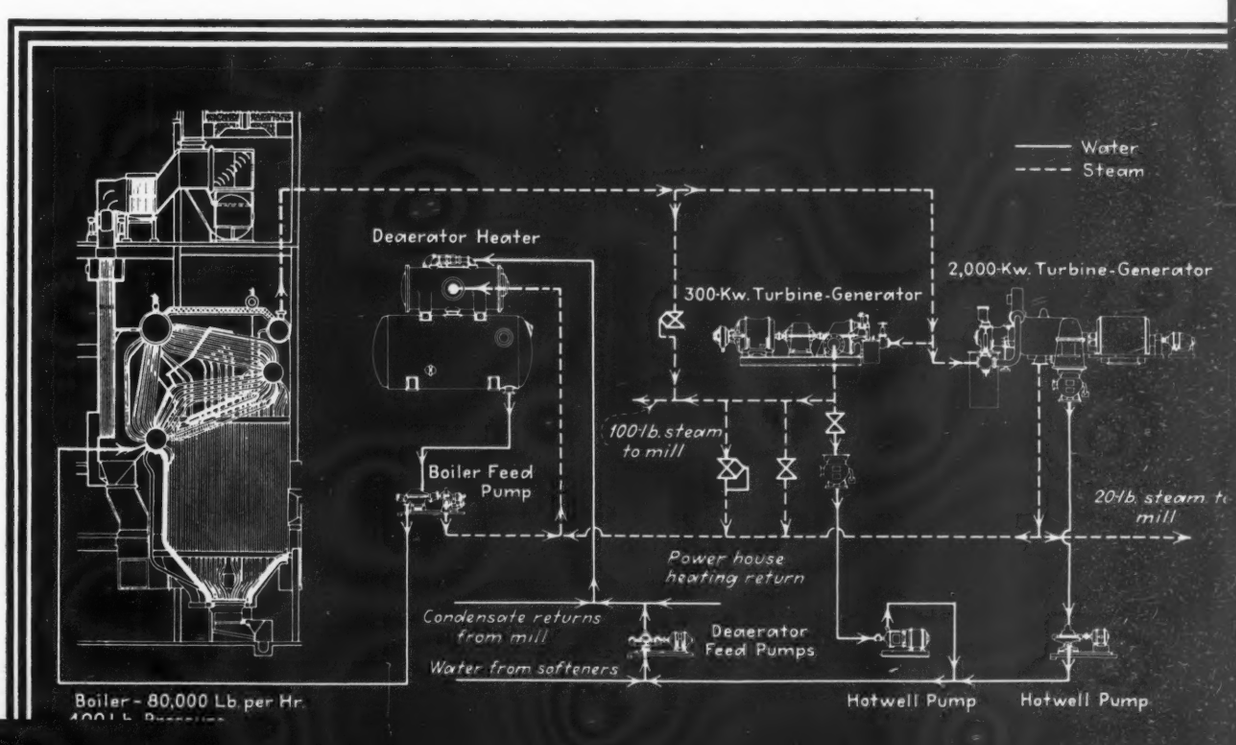
Power is generated at 550 volts, 60 cycles. Bus and oil circuit breakers below turbine-room floor. Power to mill controlled by solenoid-operated oil circuit breakers and distributed over underground cables.

Meters

Metering equipment is provided for determining quantities of power steam and water delivered to a number of mill departments for production cost purposes in addition to instruments required to guide power-plant operation.

Piping

All high-pressure steam lines are extra-heavy pipe with Sargol type flanged joints. Excepting high-pressure steam and boiler feed lines, piping has been welded whenever economically advisable. Creased or corrugated bends and welding fittings have been used extensively. Boiler leads supply steam to two cross-connected headers from which high-pressure steam is distributed. Motor-operated valves are used at these headers.



WILSON & CO., INC.

• MODERNIZATION of industrial power plant of Wilson & Co., meat packers, Chicago, Ill. Placed in operation, January, 1934. Prior to modernization, power was purchased and nine chain-grate-fired, water-tube boilers supplied steam at 150 lb. pressure to turbines and engines driving pumps and air and ammonia compressors and to processes at various pressures. About 40 per cent of prime movers operated condensing, supplying hot water for process from barometric condensers.

Power and Process Demands

Maximum power demand, 3,500 kw. Steam demand in winter, 152,000 to 260,000 lb. per hr., and in summer 116,000 to 224,000 lb. per hr., average in winter, 190,000 lb. per hr., and in summer, 151,000 lb. per hr.

Cycle

New boilers generate steam at 420 lb. pressure and 610 deg., supplying three turbine-generators. These bleed at 155 lb., supplying steam to old engine and turbine drives, and at 85 lb. to high-pressure processes and deaerating heaters. Turbines exhaust at 10 lb. pressure to low-pressure processes, building and feed-water heating. Old engines and turbines exhaust at 10 lb. pressure for heating process water and augment supply of low-pressure process steam.

Boiler Units

Three 11,220-sq.ft., 4-drum, bent-tube boilers, with convection superheaters are installed, each having capacity of 130,000 lb. of steam per hr. Alternate tubes in first bank enter second steam drum, alternate tubes in second bank enter first steam drum. Vertical economizer of 4,830 sq.ft. with top and bottom drums is included in boiler setting. Superheater headers are above boiler drums. Steam is superheated 106 deg. Flue gas leaves economizer at 527 deg.

Side walls and wall under the mud drum are sectionally supported and air cooled. Roof and wall opposite mud drum are water cooled by bare tubes, and there is a bare-tube water screen over ash hopper.

Coal Handling and Firing

Coal is received by rail and dumped into a track hopper from which it is removed by apron conveyor to 60-ton per hr. crusher. Belt conveyor and bucket elevator raise it to distributing belt over 260-ton bunker of precast reinforced concrete slabs supported on steel straps. From overhead bunkers coal is delivered to continuous weighing machines which feed it to 60-ton per hr. ball mills, two per boiler. Primary hot air removes coal from mills and delivers it to four pulverized-coal burners per boiler. These are in air-cooled wall under boiler mud drum.

Gas and Air Circuits

Above each boiler is one forced- and one induced-draft fan, each driven by synchronous motor through variable-speed hydraulic couplings. Air travels through air-cooled furnace walls to forced-draft fan of 49,000-c.f.m. capacity and then down through vertical tubular air preheaters of 13,788 sq.ft. installed directly in back of integral economizers. Temperature of air leaving air preheater is 365 deg. Air leaving preheaters divides, part going to mills as primary air and part to burners as secondary combustion air. Furnace gas passes from boiler through air preheater to induced-draft fan of 70,400 c.f.m. capacity and short steel stacks. Dust is concentrated in fan inlet cyclones. That part of flue gas in which dust is concentrated goes through secondary cyclones from which dust drops to receivers and cleaned gas goes back to induced-draft fan suction.

Ash Handling

Ash hoppers under furnaces, fly-ash hoppers between boiler and economizer, between economizer and air preheater, and cyclone dust collectors, are all connected to pneumatic ash-conveyor system. This

system delivers ash to overhead storage bin from which railroad cars are loaded through a dustless unloader.

Feed Water

Condensate returning from factory processes is treated for removal of oil and grease, filtered and pumped to a deaerating heater of 242,500-lb. per hr. capacity. Heater raises temperature of feed water to 215 to 324 deg.

City water makeup is first heated with steam at 5-lb. pressure in an open heater on top of settling tank holding one-hour supply. Hot water leaves heater through mixing throat where treatment chemicals are added, then goes to settling tank. From settling tank treated hot water goes through filter to booster pumps that feed deaerating heater. Four 310-g.p.m. feed pumps take water from deaerator heaters and deliver it to economizers. Deaerator is supplied with 80-lb. pressure steam bled from turbines. Boiler water is further conditioned by continuously drawing water from front and rear drums, filtering it, and returning it to bottom header of water-wall tubes. Any additional chemical treatment is introduced before filtering.

Turbine-Generators

Three new turbine-generators are installed in old engine room. Units are rated at 3,125, 2,500 and 1,875 kva. and 90 per cent power factor. Generators deliver 3-phase, 60-cycle current at 480 volts. Two larger turbines are arranged for bleeding at 155 and 85 lb. pressure and exhausting against 10 lb. back pressure. Smaller turbine bleeds at 155 lb. pressure and exhausts at 85 lb. back pressure. Early in 1934 load ran about 4,000 kw., requiring 172,000 lb. of steam an hour at turbine throttles. At this load 94,000 lb. an hour of 155-lb. bleed steam is available and is maximum required by old engines and turbines. Likewise, 40,000 lb. per hour of 85-lb. bleed steam is available and is sufficient to supply maximum demand of high-temperature processes. With above amounts of steam extracted there remains 38,000 lb. of 10-lb. exhaust steam. This is augmented by 56,000 lb. of exhaust from older non-condensing units. Maximum demand for 10-lb. steam is about 95,000 lb. an hour.

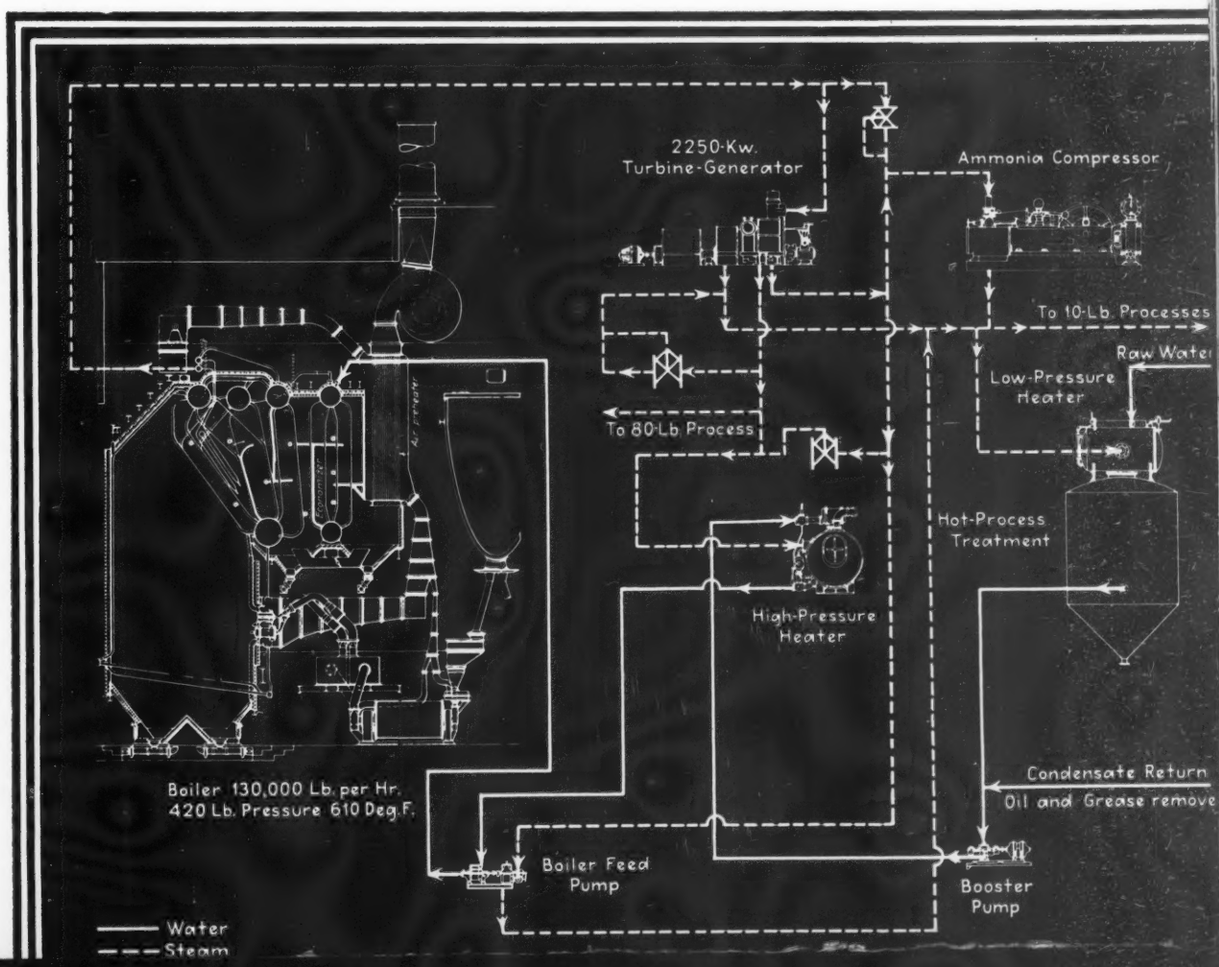
Cross-Pressure Ties

Various pressure headers are connected through pressure-reducing and desuperheating stations. This makes 155-lb. steam available from boilers, 85-lb. steam available from 155-lb. header and 10-lb. steam available from 85-lb. header.

Performance Estimates

Preliminary experience indicates new plant will save 18,000 tons of coal per year plus cost of purchased current and sixteen men. Deducting overhead, net saving will amortize plant in five years. Steam production is approximately 1,350,000,000 lb. per year. Boilers operate with an average efficiency of 85 per cent, evaporating 10.2 lb. of water per pound of coal. About 16,100,000 kw.-hr. are generated a year.

Illustration below is a flow diagram in which various units shown are outlines or cross-sections of actual equipment in plant.



SCHENECTADY

• SCHENECTADY mercury-steam plant at Schenectady, New York. Owned by General Electric Company, leased to and operated by New York Power & Light Corp., supplies steam and power to Schenectady Works and power to utility system. Engineers: A. R. Smith, General Electric Co. in cooperation with Stone & Webster Engineering Corp. and New York Power & Light Corp. Steam boiler placed in operation spring of 1933 and mercury unit fall of 1933. Present generating capacity 26,000 kw. First large so-called "out-door" plant.

Cycle

Plant operates on binary vapor cycle. Mercury vapor, generated at 125 lb. gage and 958 deg. F., expands through a mercury turbine to condenser pressure of 1.4 lb. abs., corresponding to temperature of 480 deg. Steam at 450 lb. gage is generated by condensing mercury and after superheating to 750 deg., is expanded in a steam turbine to 225 lb. pressure. Steam at this pressure is used in General Electric works for heating and process purposes.

Mercury

Mercury part of cycle generates 20,000 kw. of energy and provides 240,000 lb. of steam an hour at 450 lb. pressure for process and power generation. To obtain a similar amount of energy from an all-steam cycle providing the same quantity of steam for process would require steam initially at a pressure well above the critical and at a temperature of over 1,000 deg. F., a steam condition not now practical.

Since exhaust steam is used for process, heat chargeable to power, as in any straight by-product power generation, is about 4,500 B.t.u. per net kw.-hr. Assuming steam generated were used in an efficient condensing turbine, heat rate would be about 9,500 B.t.u. per kw.-hr. as shown by data from Kearny central station where a similar mercury unit is installed. Boiler efficiency averages 85 per cent.

Boiler Units

Plant contains one steam and one mercury boiler. Mercury boiler consists of seven parallel drums with porcupine tubes placed directly over furnace. Between these drums are mercury liquid heaters which raise temperature of mercury returning from condensers to boiler drums. Upper half of furnace walls is cooled with mercury heating surface. Lower half of walls and furnace bottom are water cooled. Steam generated in water walls discharges to two drums installed at front and rear of furnace. Mercury vapor formed in porcupine tubes and mercury walls discharges into boiler drums and from drums through corrugated pipes to two mercury vapor headers. From these headers vapor is conveyed to mercury turbines through two control valves in series.

Superheater

Convection-type counter-flow superheater above mercury boiler superheats steam from mercury condenser boiler and from the water walls to 750 deg. At full load, steam from water walls is 90,000 lb. per hr. and from mercury condensers about 240,000 lb. per hr.

Steam boiler is a cross-drum, sectional-header type of 330,000 lb. per hr. continuous capacity, generating steam at 450 lb. pressure and 750 deg. Furnace walls and bottom are protected with block-covered water walls.

Air Preheaters

Flue gas from both mercury and steam boilers passes downward through air preheaters to induced-draft fans and stack.

Coal Handling and Firing

Coal is delivered to coal crushers and then con-

veyed by bucket elevators to coal bunkers at base of two stacks and below induced-draft fans. From bunkers coal is fed to pulverizers and conveyed by primary air to burners. Pulverized coal is fed to furnace of mercury boiler at front and rear in a downward direction. Steam boiler, however, fired only from front. Ash collects in slag-tap furnace bottoms.

Mercury Turbines and Condensers

Mercury turbine is a double-flow five-stage unit of 20,000-kw. capacity, operating at 900 r.p.m. Mercury vapor enters at center and flows axially in both directions, exhausting into two condenser boilers where heat of condensation generates steam at 450 lb. pressure. Mercury vapor enters each of 10-ft.-diam. cylindrical condenser shells at two points. Water tubes, closed at bottom, extend down into shells and are arranged in lanes so that mercury vapor penetrates toward center. Safety valves on mercury boiler exhaust to condensers, by-passing turbine.

Condensed mercury is fed back to boiler by vertical centrifugal pumps. This pump and a spare pump are installed below turbine floor. It has a single-stage overhung impeller of 11-in. diameter operating at 1,800 r.p.m. Feed pump takes its suction from two mercury sumps immediately below condensers. These consist of cylindrical containers mounted at an angle of about 45 deg. Inside sumps are screens through which mercury flows and to which any dirt in mercury adheres. At intervals these screens are rotated and dirt falls off into a pocket, thus keeping mercury system clean. Mercury feed pumps make this plant unlike Hartford and Kearny mercury installations where gravity feed is secured by installing mercury turbine and condensers above the boilers.

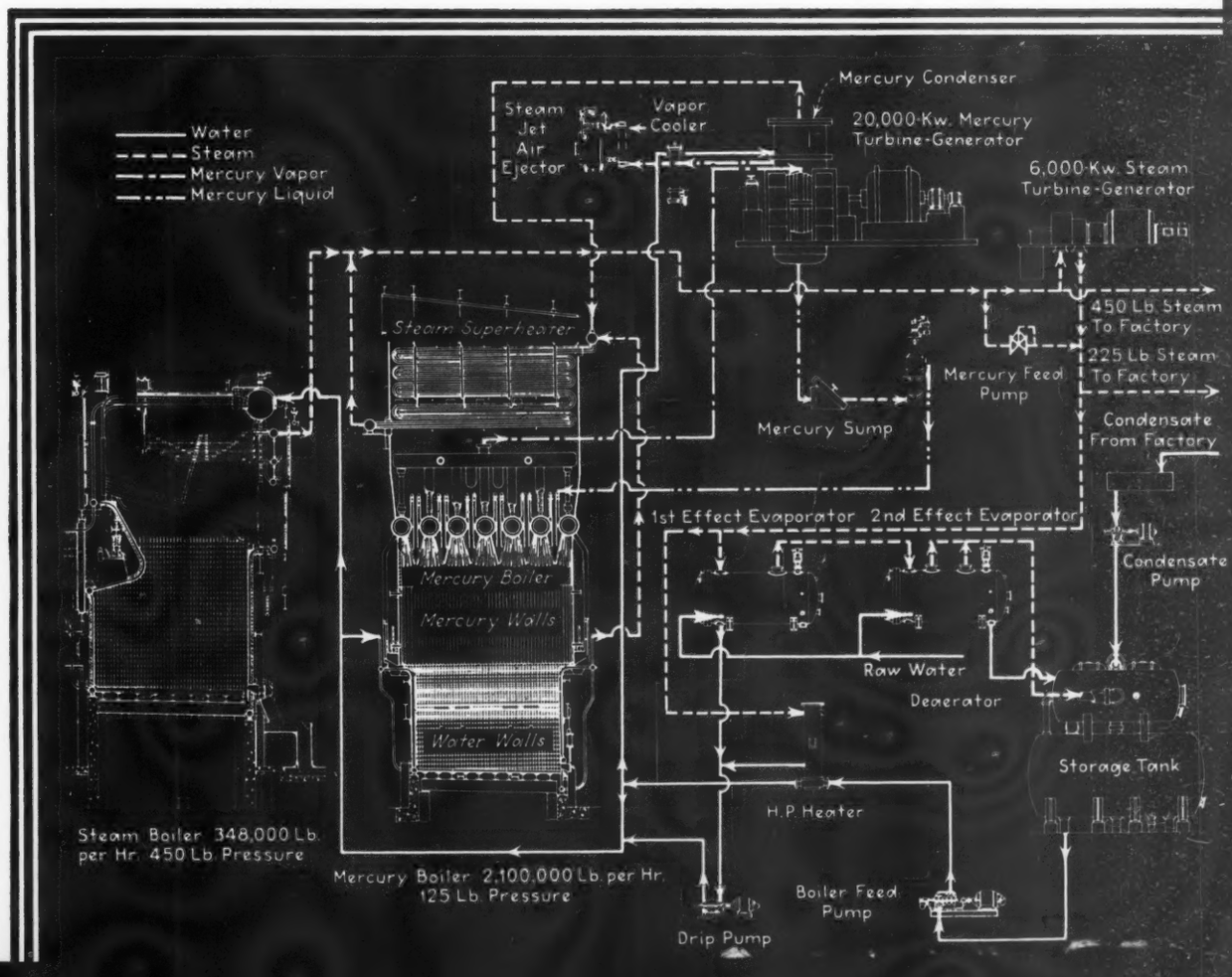
Steam Turbine

Some of the steam is received by 6,000-kw. turbine at 425 lb. from mercury condensers, steam boiler and water walls in mercury boiler. It exhausts at 225 lb. pressure, supplying steam for factory processes and power plant auxiliaries and double effect make-up evaporators. Evaporated makeup is condensed by condensate returns from factory in a deaerating feed heater.

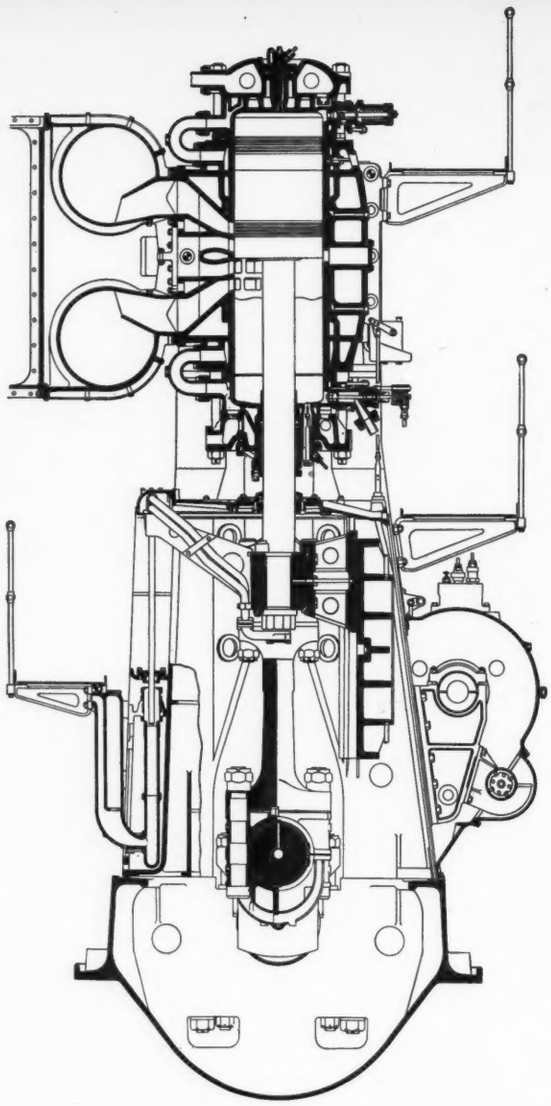
Outdoor Features

The 20,000-kw. mercury turbine generator, with its condenser and steam-jet air ejectors and 6,000-kw. steam turbine, are protected against weather and installed out-of-doors at usual turbine floor level. Deaerating feed-water heaters and evaporators are also on turbine floor.

Steam superheater casings, forced-draft fans and air-preheater casings of both steam and mercury boilers are weatherproofed and installed out-of-doors. Flue-gas ducts to and from air preheaters are also exposed to weather. Upper parts of boilers are housed separately, but their lower parts are in a common boiler room forming firing floor. Auxiliaries and switchboards are housed and also coal-handling equipment which was necessary to permit thawing coal cars during winter. Building is mostly metal, permitting easy extension.



VERNON, CALIFORNIA



• VERNON, municipal diesel-electric station at Vernon, Calif. Owned by City of Vernon. Engineers: City Engineer Howard McCurdy in charge of design and construction. First five 7,000-hp. units in operation June 19, 1933. Ultimate capacity 70,000-hp. Largest diesel station in America, second largest in the world. Largest American-built diesels.

Five 7,000-hp. double-acting, two-cycle, solid-injection diesels each with two waste-heat boilers to recover 62 per cent of exhaust heat. Complete evaporator system, first in American diesel plants. Forced-draft, spray-nozzle cooling towers serve raw-water side of heat exchangers, which cool distilled water used exclusively in engines. Lubricating oil continuously filtered through centrifuges and edge-type filters. Combustion air supplied by motor-driven centrifugal blowers. Unusually complete electrical control board and careful coordination of plant and distribution system.

Building

Designed to surround equipment properly placed and to withstand earthquakes. Structural steel and concrete, modern lines, mission stucco finish. Gross ground area 240x170 ft., building volume 1,600,000 cu.ft. Central structure, 240x73 ft. and 55 ft. high, houses engine-generators, compressors, air bottles and maintenance machine shop (separate maintenance men for repair work only) and allows space for two additional units. One end wall brick to permit expansion. Engines stand side by side, each on its own seperate concrete foundation, all served by electric crane 49 ft. above floor.

Front bay contains electrical control room, switch-gear rooms, offices and laboratories. Rear bay contains waste-heat boilers, make-up water evaporators and water-pump pit, with lubricating-oil equipment, scavenging air blowers and 550-hp. gasoline emergency set in low connecting section having air washers in light well above.

Engines

Five 6,850-b.hp., 8-cyl., double-acting, two-cycle, 24x36-in. engines. B.m.e.p. 66 lb. per sq.in. Piston speed 1,002 f.p.m. at standard engine speed of 167 r.p.m., a conservative figure. Pistons in four parts, upper steel forging, lower steel casting, cast-iron guide ring, cast-iron skirt. Water-cooled. Separate upper and lower cylinder liners with sinuous line of contact, all ports being in upper liner. Exhaust ports between head and scavenging ports, incoming air sweeping across cylinder, up to head and down to exhaust, thus making mixture-aiding loop. Cylinder heads two-piece, inner cast steel, outer cast-iron, with single spray valve in center of upper, two at sides of rod in lower.

Fuel pump and governor driven by gears from crankshaft. Governor controls power output by timing opening of bypass valve in constant-stroke injection pump. Maximum compression pressure 430 lb., scavenging air pressure 2 lb. at all loads. Full-load efficiency 36.3 per cent, rising to 37.5 per cent at three-quarter load. Heat distribution at full load is 26 per cent to cooling water, 33.7 per cent to exhaust, 4 per cent to friction and radiation. Air charge more than 250 per cent of theoretical amount needed for combustion. Blower handles 27,000 c.f.m., only 7 per cent more than cylinder volume, showing very low loss before combustion. Fuel consumption 0.364 lb. per b.hp.-hr. at full load, 0.347 at half and three-quarter load. Net figures 0.383, 0.371, 0.384 in same order.

Controls centralized in single panel at back of engine. Frequency controls avoid fluctuations by causing governor motor to change fuel-pump valve setting and thus maintain instantaneous frequency. Anti-hunting feature is provided in anticipatory and

filtering relays actuated by frequency recorder.

Generators

Enclosed type, direct-connected to each engine; 7,500-kva., 7,200-volt, 3-phase, 50-cycle, 80 per cent p.f. alternator with direct-connected, 70-kw., 250-volt, shunt-wound main exciter and 4-kw. compound-wound pilot exciter, both outside outer generator bearing. Pilot exciter used to speed response because of low-speed, high-magnetic-mass main exciter.

Generator voltage controlled by varying main exciter field, avoiding generator field rheostats. Excitation controlled by high-speed rheostatic voltage regulators on station control board.

Waste-Heat System

Evaporators provide extra distilled water to be sold. Two 100-lb. pressure waste-heat boilers per engine recover 62 per cent of exhaust heat. Gilled rings over 2-in. tubes increase heat-absorbing area six times. Boilers can be operated as mufflers only (without water) under exhaust temperatures below 750 deg. F. Total heating surface 1,872 sq.ft. per boiler. Water volume 36½ cu.ft. per boiler, generating 2,240 lb. steam per hr. at 50 lb. abs. pressure and at 87½ per cent engine rating. Gas temperature leaving boiler 360 deg. Steam heats fuel and lubricating oil before centrifuging, and supplies evaporators. Evaporators horizontal bent-tube submerged type with bowed, finned tubes. Cycle is shown below.

Combustion Air

Separate centrifugal blower for each engine, providing 27,000 c.f.m. at 2.0 lb. pressure. All air is scrubbed to eliminate dust created by sandy, semi-arid surrounding country. Scrubber two washing banks, recirculating wash water by means of pump driven by 1½-hp. motor. Water pressure 5 lb. at sprays. Special butterfly-type tilting-disk gate valve for quick regulation of air flow.

Cooling Water

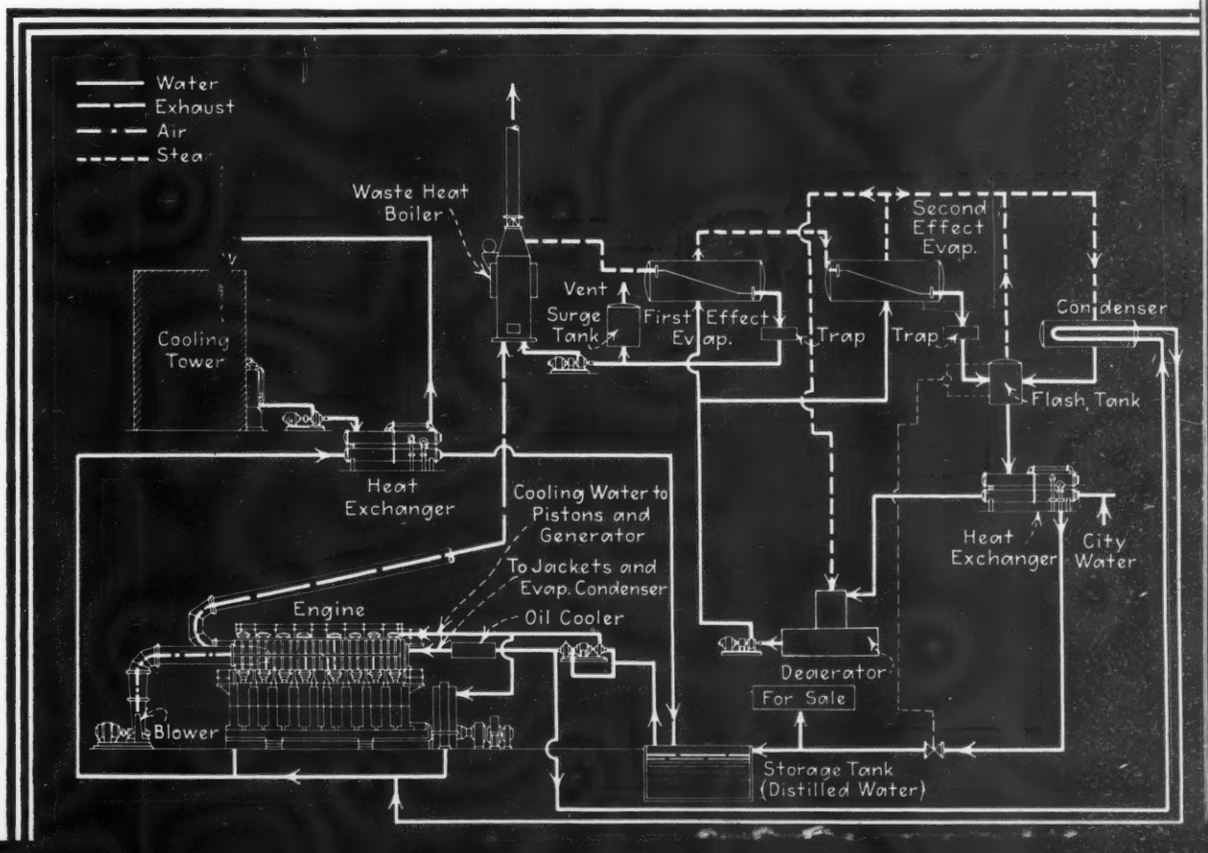
Double-circuit enclosed type, using only distilled water, as shown in diagram. Cooling system removes 14,420,000 B.t.u. per hr. per engine at full-load with 25-deg. temperature rise through engine. Water stored in closed concrete two-section reservoir, only one section being used at a time. Two centrifugal circulating pumps per engine, one spare set for plant. Cooling towers forced-draft type in one long structure, with divisions for each engine. Each section will dissipate 17,170,000 B.t.u. per hr. from engine, generator cooler, oil cooler, and condenser water drop of 20 deg. from 95 to 75 deg. F. Evaporation loss 1½ to 2 per cent, drift loss below 0.1.

Lubricating Oil

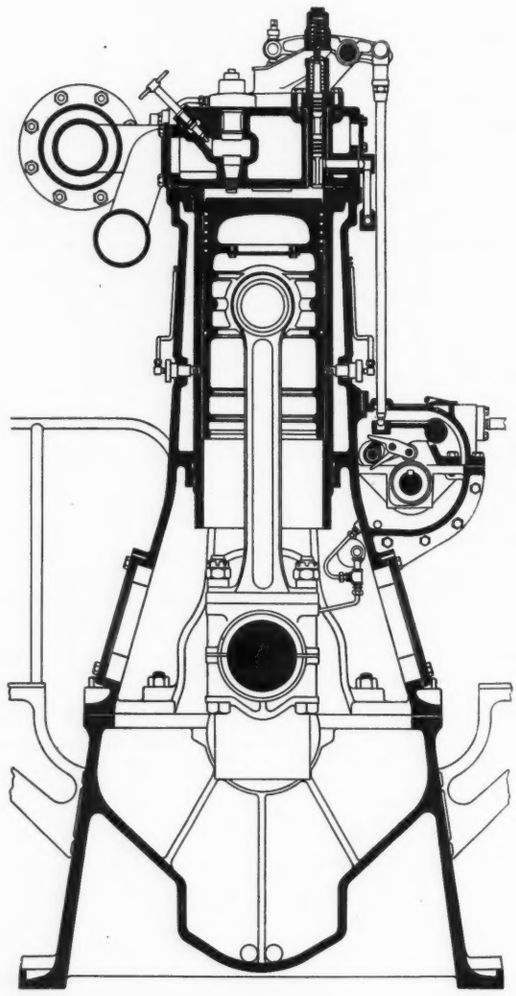
From tank car to yard tanks. Unloading gear pumps also transfer oil to 400-gal. roof tank. Oil runs by gravity to header, thence to direct-acting lubricators oiling 40 deg. before top dead center and 35 deg. before bottom dead center. Bearing oil pumped to engine sump. Crankcase oil system separate. Includes 200-g.p.m. auxiliary motor-driven gear pump for standby, filters and cooler. Present circulating oil 500 sec. Saybolt at 100 deg. F., cylinder oil 78 sec. Saybolt at 210 deg., motor and pump bearings 150 sec. at 100 deg. F. turbine oil.

Fuel Oil

Two large tanks, one 399,000, other 630,000 gal., store oil for 600-hr. capacity run, thus permit economical buying. All fuel filtered and centrifuged. Oil meter in line from tank car, another in line from day tank to engine. Present fuel 26.6 A.P.I. gravity, 178 deg. F. flash, 65 sec. viscosity at 100 deg. F. and 1.64 per cent carbon residue.



ONE PARK AVENUE



• NUMBER ONE PARK AVE., automatic diesel-electric building plant at this address in New York, N. Y. Owned by Number One Park Avenue Corp. Engineers: design, Chicago Pneumatic Tool Co.; installation, Erickson Equipment Co., Inc. In operation October, 1932.

This completely automatic, 4-engine, 1,080-hp. diesel plant supplies all electrical current and some hot water. Advanced in use of automatic control, complete isolation and silencing, extensive use of auxiliary equipment, battery-booster to prevent voltage fluctuations, and independence of standby. Its engines are direct-connected to direct-current generators and are tied in with a battery and motor-generator booster set, all controls being centralized on one switchboard. Electrical devices start or stop one or more engines automatically, cut out and warn of a defective engine, start another automatically, and maintain running capacity 25 per cent above existing load.

Engine-Generators

Four 6-cyl., $10\frac{3}{4}$x$13\frac{3}{4}$-in. 270-hp. at 360-r.p.m. engines have full-load fuel consumption of 0.42 lb. per b.hp.-hr. At three-quarter load, fuel consumption is 0.45, at half load 0.50, at quarter load 0.66. Generators are 250-volt, 3-wire, direct-current units with special flat-compound windings and special high-torque windings for starting. Three engines will carry full load; fourth is a spare. A pyrometer element in each cylinder exhaust line leads to 12-contact pyrometers, one pyrometer thus serving two engines.

Battery and Booster

The 1318-amp.-hr., 250-volt storage battery carries momentary load peaks and load temporarily, should one engine develop trouble. Motor generator booster is connected to battery and busbars in such a way that it builds up voltage on sharp rises in current flow (which would ordinarily cause drops) and on sharp dips it reverses its action and uses excess generated current to charge battery. This automatically holds line voltage constant. If peak or dip lengthens out, control automatically starts or stops another engine. If trouble develops in an engine, control cuts it out, warns of trouble, and substitutes another engine. In this way, which permits reasonable engine loading at all times, automatic plant can be of much lower capacity than an equivalent manual-control plant, thus costs less than would manual-control plant and battery required for same building load. All electrical cables and connections are heavy enough to stand any load encountered without overheating and thus causing service interrup tions.

Isolation

Plant is in a sub-basement room, $22\frac{1}{2}$x$62\frac{1}{4}$ ft., planned originally for a boiler room, but not so used when it was decided to purchase steam. Solid rock is 20 to 24 in. below concrete floor. A 42x18-ft. area was cut down to bed rock, rock surface irregularities filled with concrete, and 3-in. layer of cork isolation laid over it. This cork is in strips, designed for loading of 1,500 lb. per sq.ft. A 1-in. layer was also set around edges of pit, and a slab of concrete 3 ft. thick poured in this box. Cork prevents vibration from reaching building, and center of gravity of slab is so low that little torque is exerted.

Fuel-Oil Storage

To avoid uncertainties of oil supply, a 5,000-gal. steel tank, all arc-welded, holds a full week's supply. It is also set on rock in a pit with concrete dike built up around it to hold its full capacity should a leak develop. This is required by fire ordinances, as is placing of 2½-in. brass fuel return line from reservoirs above tank and 3 ft. above floor. Engine auxiliary fuel pumps lift oil through individual lines to small reservoirs above injection pumps, with overflow lines leading into main fuel return line. Telegage on tank shows daily fuel consumption.

Lubrication

All bearings are pressure-lubricated, oil being continuously cooled and screened. A double set of pumps and tanks is provided so that oil from one set may be drawn off and centrifuged while other is in use. A rotary pump driven from idler gear on camshaft drive, takes oil from crankcase sump and passes it through filter and shell-and-tube cooler. Engine makeup water acts as coolant, and since its quantity varies with engine loading, it automatically controls lubricating-oil temperature. In case oil supply fails, a pressure diaphragm in line operates a mercoid switch which in turn opens circuit to a solenoid which permits an engaging device to hold engine exhaust-valve pushrods open.

Circulating Water

It is essential that water supply be maintained at any cost. Consequently, connections are made to city mains on both Thirty-third and Thirty-second Sts., and there is also a house-tank on building roof large enough to supply water for three days. A motor-driven pump in building machine room is connected to engine water header through pressure-reducing valve. If city water pressure fails, this valve opens to admit water from tank. To avoid any failure, building sprinkler system is connected to an entirely different tank and pipe system.

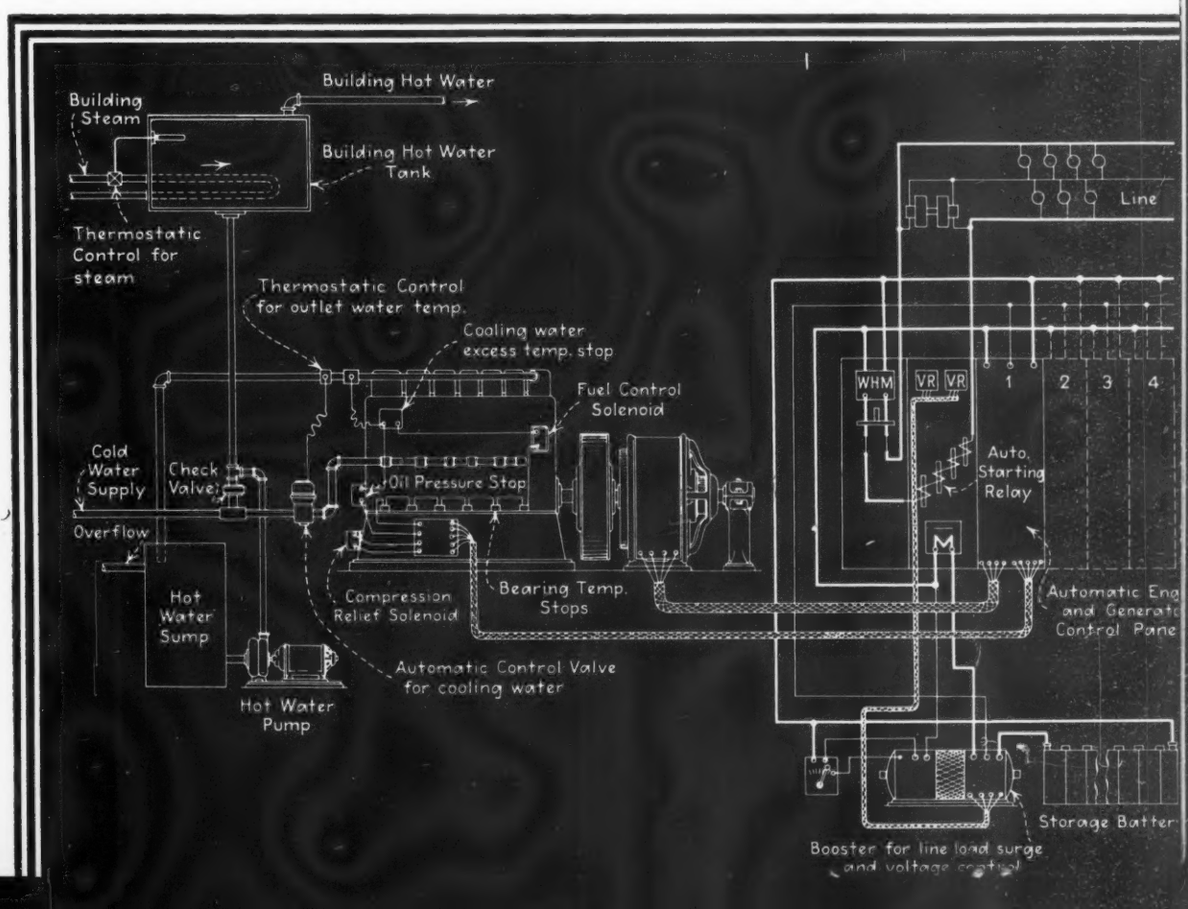
Engine cooling water is recirculated to keep liner temperature uniform. A small motor-driven centrifugal pump picks up part of warm water from jackets and with 50-deg. makeup, recirculates it. A thermostatically operated valve in makeup line governs amount added so that incoming water is at 115 deg., exit water at 135 deg., thus recirculating *all* jacket water while engine is warming up. This control betters' engine performance and also provides heated water which is metered to building, saving $4,000 a year for hot-water heating.

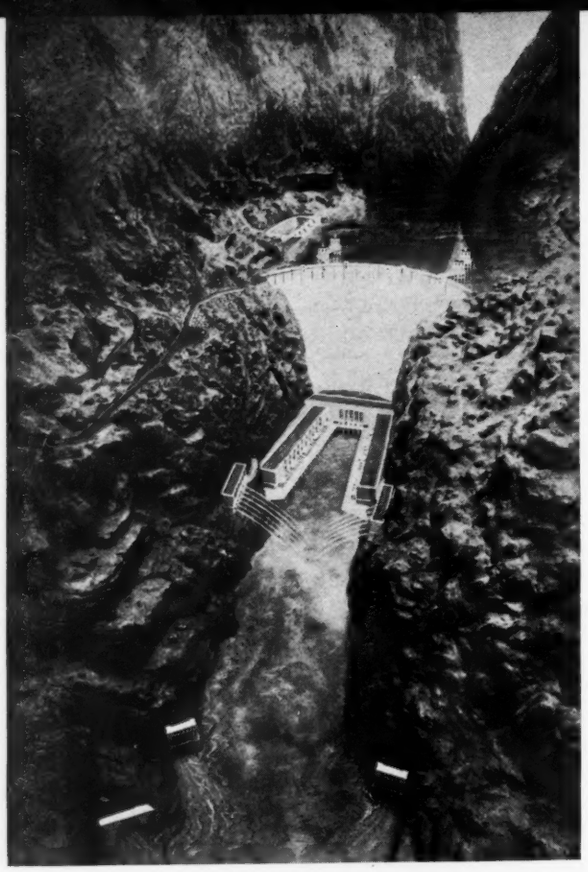
Intake and Exhaust Air

Engines take their air from room. Though ceilings are high, any fouling or overheating of engine room is avoided by a fan, powered by a 5-hp. motor, pulling outside air down through a spare elevator shaft to provide a complete air change every two minutes. Of the 22,000 cu.ft. of filtered air supplied per minute, engine uses 2,800, excess passing out through a brick stack built for former proposed boiler plant. Combustion air is drawn through manifolds equipped with silencers. Exhaust lines pass to foot of brick stack and there carry silencers and two-pipe expansion chambers, then extend 20 ft. further up into stack. To prevent transmission of any pipe-line vibration to building, they are carried on special hangers and include sections of flexible metallic hose.

Battery room has its own ventilating system to change its air every six minutes. An acid-proof blower motor and fan operate in a lead-lined exhaust duct leading to brick stack.

Operation so far has indicated that plant will pay for itself in five years in power saving.





BOULDER DAM

• BOULDER DAM power and water project in Black Canyon on the Colorado River, about 30 mi. from Las Vegas, Nevada. One of world's greatest engineering undertakings. Includes world's largest tunnels, highest dam, largest artificial storage reservoir and most powerful hydro-electric units. Funds for construction provided by United States Public Works Administration of which Harold L. Ickes, Secretary of Interior, is Administrator. Construction by Six Companies at contract price of $49,000,000, and estimated total cost of dam and power plant $108,800,000. Actual construction began July, 1931. Initial power generation expected late 1935.

Colorado River flow studies indicate that when power plant is completed, 4,330,000,000 kw.hr. of primary power and 1,550,000,000 kw.hr. of secondary power can be generated annually. Contracts have been made with state, municipal and public-utility interests for this power at rates that will amortize cost of project in 50 years and also provide $166,000,000 in surplus revenues.

These contracts provide that City of Los Angeles shall operate part of plant and generate power for itself, States of Nevada and Arizona, Metropolitan Water District and for several small municipalities and that Southern California Edison Company shall operate remainder and generate power for itself and other public utilities. From 73 to 91 per cent of the power will be generated by Los Angeles and 27 to 9 per cent by Southern California Edison Co.

Even though this project includes one of world's greatest power developments, it is primarily a water-supply and river-control undertaking. Storage reservoir will eliminate a serious flood menace to a large area along several hundred miles of river below dam. Eventually, Metropolitan Water District of Southern California, centering around Los Angeles, will take 1,000,000,000 gal. of water per day from river through an aqueduct 250 mi. long and will require 400,000 hp. for pumping. Water will be available in reservoir storage for irrigation of 2,000,000 acres in Nevada, Southern California and Arizona.

Tunnels, Dams

Dam 730 ft. high, now about 50 per cent completed, is more than 300 ft. higher than any other constructed or contemplated. Because of its large mass, it is necessary to cool concrete during construction with refrigerated water circulated through a system of pipes cast into dam. It will form a reservoir 115 mi. long with 30,000,000 acre-feet of storage capacity, sufficient to hold three years' flow of river.

Power house will be U-shaped, with wing on each side of river and central portion resting on dam's downstream toe. One-half of generating units will be on each side of river, with switchboards, offices, machine shops and auxiliary equipment between. Space in power house will provide for installation of 1,835,000 hp., of which 515,000 hp. have been ordered.

U-shaped power house was selected to accommodate large number of units required within restricted space between canyon walls immediately below dam. It also permitted minimum length of penstocks and allowed maximum permanent use of four diversion tunnels.

Four concrete-lined tunnels, each 50 ft. in diameter, are required for river diversion during construction around damsite. Afterward, two will be converted into spillway discharge conduits. Other two, one on each side of river, will be lined for 30-ft. diameter steel-plate outlet pipes and will connect reservoir to turbine penstocks and bypass valves. The latter will divert water for irrigation around power plant, at times when turbine discharge is not sufficient. In addition to these, two 30-ft. pipes will be installed in 37-ft. diameter tunnels constructed especially for this purpose.

Power Plant

Power-plant space is being provided for ultimate installation of fifteen vertical-shaft francis turbines rated at 115,000 hp. and two of 55,000 hp., when operating under 500-ft. net effective head. Head will vary from 420 to 590 ft., with average about 520 ft. Initial installation will consist of four 115,000-hp. and one 55,000-hp. unit. It is planned to start operation when head of 420 ft. is available. At that head large wheels will develop 90,000 hp.

each. They are designed for maximum head of 590 ft., at which, with full gate, they would develop about 156,000 hp. Turbine gates are to be blocked when head exceeds 500 ft. so that at no time will wheels deliver more than 115,000 hp. to generators.

Four large units being installed are for Bureau of Power and Light, City of Los Angeles. They are being designed to operate at either 150 r.p.m. when 50-cycle power is required, or at 180 r.p.m. when 60-cycle power is needed. Runners will be changed with frequency to obtain maximum efficiency.

Valves, Governors

Because of pipeline and penstock lengths, pressure regulator valves are necessary on turbines to limit pressure rise to a safe value. Each will be provided with one of these valves capable of discharging 80 per cent of turbine full-load flow. They are governor-operated by mechanical connection to gate-shifting mechanism. Discharge from valves is vertically downward into energy absorbers immediately below.

A 14-ft. diameter butterfly valve will be installed at scroll-case inlet to each 115,000-hp. turbine. These valves will be operated by oil at 1,000 lb. per sq.in. pressure, supplied by individual motor-driven pump for each valve. They are to be arranged for remote control, and sequence of operation will be interlocked so that a turbine can be put into or taken out of service by switchboard operator without attention from a floor man.

Each governor actuator is driven by a direct-connected motor, supplied with power from an independent generator of a permanent-magnet type mounted on top end of main shaft. Governors and servo-motors are designed for operation with 300-lb. pressure oil instead of customary 200-lb. pressure. This has reduced cost of turbines and governors. Governors and governor oil pumps are at turbine-floor elevation, which permits short, direct pipe connections between actuator and servo-motors on each turbine and allows centralizing control for turbine, governor and butterfly valve.

Generators

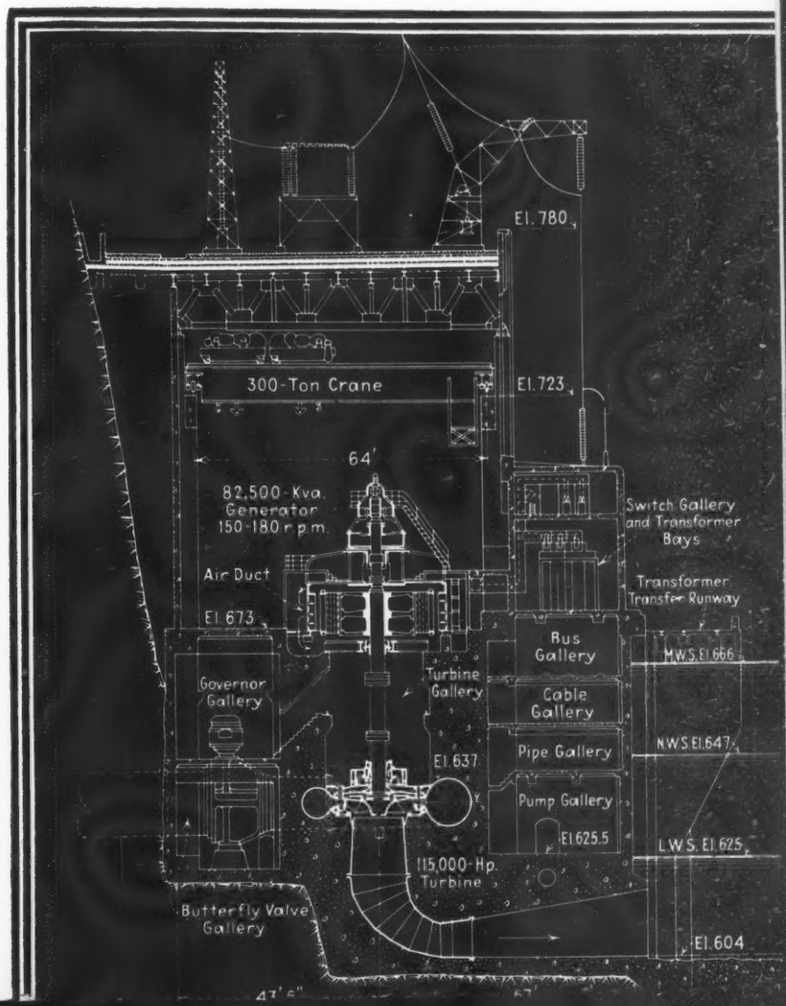
Generators driven by large turbines in initial installation are designed for 82,500 kva. at unity power factor and frequency of 50 or 60 cycles. At lower frequency they will generate 13,800 volts, at 60 cycles, 16,500 volts. After making exhaustive studies of existing transmission-line designs and performance, the Los Angeles Bureau of Power & Light decided to build two 287,000-volt transmission lines from Boulder Dam to Los Angeles. These circuits will be 270 mi. long and when operating in parallel can transmit full-load output of four 82,500-kva. generators. These transmission lines will operate at 275,000 volts at receiving end and from 280,000 to 330,000 volts at sending end.

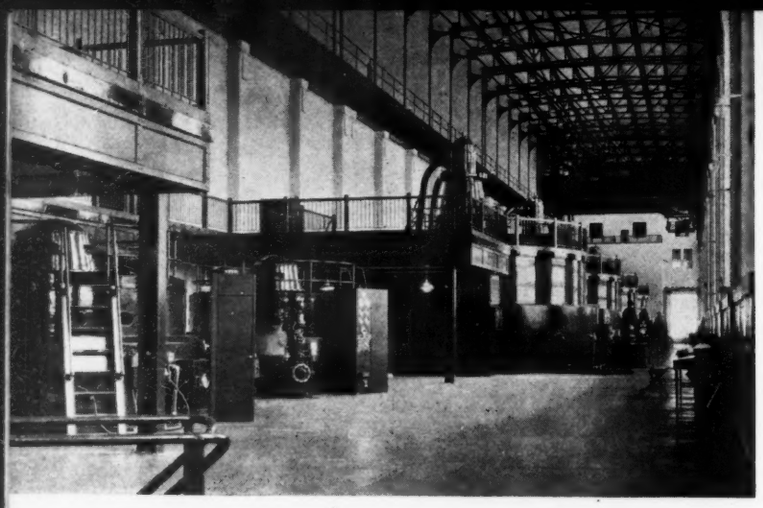
Generator electric characteristics were selected to obtain maximum transmission-line stability, as continuity of service is of primary importance. They have an unsaturated, direct-axis, transient reactance of 21 per cent, a short-circuit ratio of 2.4 and a flywheel effect of 110,000,000 lb. at one-foot radius.

Each generator will be 40 ft. in diameter and 32 ft. high, will weigh in excess of 1,000 tons, and thrust-bearing load will be 788 tons. Totally inclosed ventilation has been provided for generators, using recirculated air cooled by water in surface coolers placed radially around stator. This system of ventilation was adopted because it insures clean windings and reduces outage time for maintenance, it will afford better control of generator temperatures, which is of unusual importance because of high summer temperatures encountered in canyon; and an inclosed cooling system permits using carbon-dioxide or similar fire-extinguishing facilities.

Two generators will normally operate in parallel and will connect to a bank of three single-phase, 55,000-kva. step-up transformers connected delta on low-voltage and star on high-voltage side. Two oil switches are provided between each generator and its transformer bank.

All design work and supervision of construction is being done by Engineering Department, U. S. Bureau of Reclamation, of which Dr. Elwood Mead is commissioner; R. F. Walter, chief engineer; J. L. Savage, chief designing engineer; L. N. McClellan, chief electrical engineer; and Walker R. Young, construction engineer. Frank T. Crowe is construction engineer for Six Companies, builders.





SAFE HARBOR

• SAFE HARBOR plant of Safe Harbor Water Power Corporation. One of three great hydro-electric developments that utilize practically total head, 225 ft., of Susquehanna River between tide-water and Columbia, Pa., a distance of 40 miles. When these plants are completed they will have installed 1,265,000 hp. capacity, of which 800,000 hp. is now in operation or is being installed. All developments operate as run-of-river plants with sizable local pondage.

Several features of Safe Harbor give it a prominent position among world's outstanding hydro-electric developments. It has Kaplan-type turbines which hold world's record for capacity, and is first large installation of this type outside of Europe. There is being installed largest single-phase generator ever built and first waterwheel generator built in this country for spring mounting. Plant has larger capacity than any other in operation at equal or lower head and will have an output of over 800,000,000 kw.-hr. per year from first six units alone.

Dam and Gates

Dam is about 10 miles below Columbia, Pa., is 5,000 ft. long and forms lake 10 sq.mi. in area. This structure comprises power house 916 ft. long, bulkhead and abutments 2,274 ft., and spillway 1,810 ft. Thirty-two crest gates 35 ft. high by 48 ft. wide occupy entire length of spillway. At normal forebay level each gate will discharge 30,000 sec.-ft., thus can handle maximum recorded flood of 725,000 c.f.s. with ample margin of safety even without allowance for plant discharge. Twenty-eight of these gates are single-leaf Stony type and four are double-leaf regulating type. Latter have Stony-type lower leaf and fixed-roller type upper leaf. There are also two emergency gates with fixed rollers, which may be used in any opening.

On regulating gates, upper leaves are normally lowered to discharge water over them. These are operated by individual motor-driven hoists in dam directly under spillway. They are controlled from power-house main switchboard and are used to maintain close regulation of pond level and to dispose of floating ice and debris.

Two 150-ton gantry cranes on dam handle spillway crest gates. To insure operation of these gates under worst weather conditions, large excess crane capacity has been provided; one crane can handle gates rapidly enough to meet any normal-flood conditions; cranes can be supplied from two different power sources and one contains an emergency gasoline engine; roller tracks and seal plates of gates can be electrically heated; and compressed-air bubbling system prevents ice formation on upstream faces of gates.

Power House

Power-house concrete substructure is part of dam and designed for seven main units and two service units, forming structure 610 ft. long. Intakes for five future main units have been constructed in dam and provisions made so that the draft tubes for them may be built at relatively low cost when they are required.

Each unit has three intakes, protected by rack bars of streamline cross-section spaced 6 in. apart. It was found that streamlining bars did not add materially to their cost.

Gate with fixed rollers and screw hoist provided in center intake to each wheel. This gate fills penstock and shuts off water to it. Other two intakes are equipped with plain sliding gates raised by either one of two intake-deck gantry cranes.

Turbines

Five types of runners were considered when turbines were selected: (1) francis, (2) fixed-blade propeller, (3) manually adjustable-blade propeller; unit shut down to make adjustment, (4) manually adjustable-blade propeller, adjustment made when unit is in service, (5) automatically adjusted-blade Kaplan, blade pitch controlled by speed governor.

Because of its large space requirements and rapid loss of capacity under reduced head caused by floods, francis type was considered unsuitable. Manually-adjusted-blade-type propeller runners, adjustment being made when unit is shut down, were also held unsuited to expected load and head conditions. Difference in cost between runners designed so blades could be adjusted manually when running and those with automatically adjusted blades was not sufficient to justify former. High sustained efficiency of Kaplan type over wide ranges of load and its higher output under reduced head during flood conditions offset its 15 to 20 per cent higher cost over fixed-blade type. Combination of these two types would have met existing conditions when plant was designed. It was evident, however, that these conditions would change and that it might be desirable to operate plant in sections to serve future load requirements. These conditions and advantages of uniform design led to selecting Kaplan-type turbines.

Five 60-cycle main units, 109.1 r.p.m., are now in operation and sixth unit, 100 r.p.m., designed for 25-cycle single-phase supply to Pennsylvania Railroad, is being installed. Rated at 42,500 hp., 55 ft. effec-

tive head. Two 3,100-hp., 180-r.p.m., francis turbines driving service generators are also part of initial installation. As already mentioned, these Kaplan turbines are the highest powered in world, having runners 18 ft. 4 in. in diameter, and will discharge about 9,000 sec.-ft. at full gate and normal head. To prevent cavitation, runners are set so that centerline is 7 ft. below normal tailwater elevation, this setting being determined by extensive tests in Pennsylvania Water & Power Company's hydraulic laboratory at Holtwood plant.

Two ways have been provided for unwatering wheel casings. Units are equipped so that, as gates reach no-load position, air valves can be opened to admit compressed air to wheel casings. With gates closed, air pressure will be maintained automatically to keep runner free of water and thus allow it to rotate freely when unit is operating as a condenser. Method of unwatering for inspection is to put stoplogs in draft-tube discharge end and pump out water. Two portable unwatering pumps on special bedplates in unwatering tunnel are provided for this purpose.

Provisions are also made for steaming wheel casings to protect against frazil ice and to cleanse and dry them before men are permitted to work in them for an extended period. Steam for these purposes and for heating is supplied by two 1,000-sq.ft. boilers that may be operated up to 400 per cent of rating.

Governors

Governors on main turbines have to regulate speed and adjust runner-blade pitch. To provide for this, governor pressure oil tanks have about double capacity of those for fixed-blade turbines of equal power. Each unit of a pair has its own governor but draws its oil from a battery of pressure tanks supplied by two pumps, which together with a sump tank are common to both units. Governor oil pumps, actuators and pressure tanks are on generator floor, which is operating level. As oil pressure systems for each pair of units are interconnected, normally one oil pump delivers sufficient oil for two machines. Should this pump fail to maintain pressures, second will start automatically.

Governor actuator is motor-driven by power supplied from three slip rings on pilot exciter, at 162 volts and 7.27 cycles. Once a unit is started, gates will not open beyond speed-no-load position until actuator motor is energized by three-phase voltage, unless automatic shutdown device is raised by a button which cannot be left accidentally in raised position. Inherent speed drop can be adjusted within fairly wide limits during operation. Recently a supplementary hump has been added to standard equalizer cam to give exceptionally heavy speed droop at gate corresponding to speed-no-load. This has been found on test to be very effective in preventing hunting and permits governor to resume a constant speed within ten seconds after a sudden drop of half rated load. By extending this same idea to cutting cam to a special profile, any desired relation between speed and gate may be obtained.

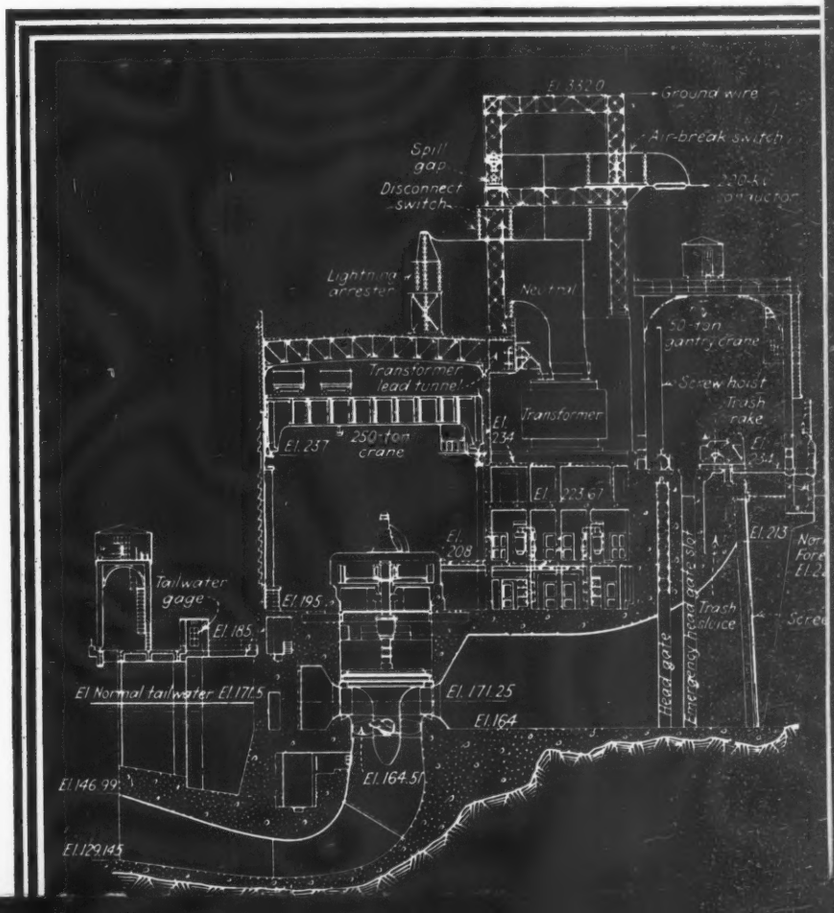
Gates of a Kaplan turbine are regulated in same manner as for a fixed-blade propeller or a francis wheel. There is, however, a supplementary valve actuated by gate movement which admits oil to blade servo-motor cylinder. This valve is then closed by a restoring mechanism as soon as movement of blades is accomplished. By inserting cam in connection from gates, any desired relation between blade and gate may be obtained.

Generators

Three-phase, 60-cycle, 13,800-volt generators rated normally 28,000 kw. at 0.9 power factor are installed on five units now in operation. They are designed mechanically for maximum rating of 36,000 kva. at 0.8 power factor and have sufficient field and exciter capacity to operate at normal kilowatt rating and 0.80 power factor.

Generators are of overhung-rotor type and have closed system of ventilation. Combination thrust bearing and single segmental-shoe guide bearing located below rotor. Thrust bearing designed for total load of 1,500,000 lb. and rotor to stand speed of 231 per cent of normal.

By end of this year, sixth unit will be installed, which will have a single-phase, 25-cycle generator rated at 35,000 kva., 0.80 power factor. As previously mentioned, it will be largest single-phase machine ever built and first waterwheel generator built in this country for spring mounting. An outdoor type, 60-to-25 cycle frequency changer with single-phase rating of 25,000 kw. at 0.80 power factor is also being installed. This single-phase power will be supplied to Pennsylvania Railroad Company's electrification between Baltimore and Washington.



High-Pressure

Data for Installations of 300 lb. Pressure and Above in the United States and Canada

Compiled by F. A. Annett
Associate Editor

Company and Location	Kind of Industry	Initial Operation	No. of Boilers	Max. Cap., Each 1,000 Lb. per Hr.	Gage Pressure, Lb. per Sq. In.	Steam Temp. Deg. F.	Boiler Heating Surface, Sq. Ft.	Water-Wall Surface, Sq. Ft.	Furnace Volume, Cu. Ft.	B.T.U. Liberated, Max., per Cu. Ft. per Hr.	Economizer Surface, Sq. Ft.
Pressures 700 Lb. and Above											
Philip Carey Mfg. Co., Lockland, O.	Heat Ins.	1931	2	150	1,840	800	4,696	2,800	9,700	20,600	5,930
Firestone Tire & Rubber Co., Akron, O.	Rubber	1934	1	300	1,400	760	11,793	7,584	14,500	24,100	8,110
Ford Motor Co., Dearborn, Mich.	Automobile	1931	2	700	1,350	750	32,040	5,130	28,500	50,000	14,000
Solvay Process Co., Syracuse, N. Y.	Chemical	1927	2	....	825	750	6,598	.....	.....	.....	4,500
Goodyear Tire & Rubber Co., Akron, O.	Rubber	1934	1	300	800	740	20,130	2,780	32,700	.....	.....
Firestone Tire & Rubber Co., Los Angeles, Cal.	Rubber	....	1	...	710	700	8,430	650	7,350	20,600	11,780
Pressures 500 Lb. to 699 Lb.											
Champion Coated Paper Co., Hamilton, O.	Paper	1930	1	343	650	750	27,190	2,620	19,080	23,000	.....
Humble Oil & Refining Co., Baytown, Tex.	Oil Ref.	1931	2	350	650	750	19,050	1,736	.....	.....	5,544
Standard Oil Co. of N. J., Bayway, N. J.	Oil Ref.	1933	2	300	650	725	.....	....	.....	.....	.....
Standard Oil Co. of N. J., Canton, Md.	Oil Ref.	1934	..	...	600	700	.....	....	.....	.....	.....
Waldorf Paper Products Co., St. Paul, Minn.	Paper	1929	2	180	650	750	13,460	1,380	11,700	18,000	.....
West Virginia Pulp & Paper Co., Piedmont, W. Va.	Paper	1929	1	140	600	750	9,000	3,500	9,000	21,200	.....
		1934	1	400	636	750	15,600	6,500	18,000	31,000	.....
West Virginia Pulp & Paper Co., Tyrone, Pa.	Paper	1928	2	100	600	750	8,460	2,708	8,670	16,000	.....
West Virginia Pulp & Paper Co., Covington, Va.	Paper	1926	4	120	425	750	8,350	1,200	6,300	23,100	1,728
		1934	1	400	600	750	15,600	6,500	18,200	31,000	.....
Anheuser Busch, Inc., St. Louis, Mo.	Beer	1930	3	150	500	600	10,760	2,000	8,750	20,000	.....
Westinghouse Electric & Mfg. Co., Mansfield, O.	Electric	1933	1	38	500	750	5,000	100	1,600	.....	.....
Pressures 400 Lb. to 499 Lb.											
Advance Bag & Paper Co., Hodge, La.	Paper	1927	5	...	400	...	7,500	....	.....	.....	.....
American Tobacco Co., Richmond, Va.	Tobacco	1930	3	38	450	600	5,030	....	.....	.....	.....
American Tobacco Co., Reidsville, N. C.	Tobacco	1928	3	...	450	600	4,690	....	.....	.....	.....
Anglo Canadian Pulp & Paper Co., Limoilou, Que.	Paper	1928	3	120	400	550	12,530	500	3,950	41,600	.....
Barber Asphalt Co., Madison, Ill.	Roofing	1929	2	51	400	550	5,470	....	3,600	15,600	.....
Blandin Paper Co., Grand Rapids, Minn.	Paper	1932	1	90	450	648	.....	.....	.....	.....	1,400
Bogalusa Paper Co., Bogalusa, La.	Paper	1926	1	90	450	650	10,200	1,090	6,200	20,000	.....
		1933	1	175	450	710	10,200	1,052	4,500	50,000	.....
Celanese Corp., Cumberland, Md.	Textile	1930	4	....	450	...	10,000	.....	.....	.....	.....
Champion Fibre Co., Canton, N. C.	Paper	1928	2	300	450	700	18,280	3,620	15,150	25,300	6,110
Champion International Co., Lawrence, Mass.	Paper	1929	2	55	400	600	5,520	76	1,600	57,000	.....
Chesapeake Corp., West Point, Va.	.....	1926	7	...	450	550	17,000	....	.....	.....	.....
Consolidated W. Pr. & Paper Co., Wis. Rapids, Wis.	Paper	1927	4	...	400	700	8,150	....	.....	.....	2,020
Phelps Dodge Corp., Bisbee, Ariz.	Copper	1929	2	55	400	650	7,250	....	2,800	32,700	.....
Crocker Burbank Co., Fitchburg, Mass.	Paper	1929	5	60	400	625	5,000	368	3,450	24,000	2,500
		1933	2	600	400	...	5,000	...	.....	.....	2,500
Jacob E. Decker & Sons, Mason City, Ia.	Meat Packing	1932	2	60	450	650	4,840	1,025	4,500	19,700	.....
DeLaval Steam Turbine Co., Trenton, N. J.	Pr. Mach.	1927	2	55	400	550	4,650	440	.....	.....	.....
Dow Chemical Co., Midland, Mich. (See 300-lb. sec.)	Chemical	1930	1	170	448	625	15,000	2,300	13,670	17,000	.....
		1934	1	350	490	725	26,700	4,700	22,000	21,600	13,670
Du Pont Rayon Co., Richmond, Va.	Textile	1928	3	...	450	700	8,000	.....	.....	.....	.....
Du Pont Rayon Co., Waynesboro, Va.	Textile	1929	3	...	450	700	8,500	1,200	5,400	23,400	1,580
Elliott Company, Jeanette, Pa.	Pr. Mach.	1927	1	...	400	750	3,270	....	.....	.....	.....
		1930	1	50	400	Sat.	6,154	....	.....	.....	.....
Forstman Woolen Co., Garfield, N. J.	Textile	1933	2	95	450	610	6,500	2,900	4,500	25,000	.....
Gates Rubber Co., Denver, Colo.	Rubber	....	2	...	400	600	6,130	....	.....	.....	2,380
Great Lakes Paper Co., Ft. William, Ont.	Paper	1928	4	120	450	630	10,000	1,033	.....	.....	.....
Gulf States Paper Corp., Holt, Ala.	Paper	1929	3	...	450	650	10,230	....	.....	.....	.....
Gulf States Paper Co., Tuscaloosa, Ala.	Paper	1929	1	90	450	650	10,300	....	7,500	20,000	.....
Gulf States Steel Co., Alabama City, Ala.	Steel	1930	4	...	400	700	9,070	....	.....	.....	.....
Hershey Chocolate Corp., Hershey, Pa.	Chocolate	1931	3	150	408	650	11,300	1,450	8,300	24,000	.....
Hollingsworth & Whitney Co., Winslow, Me.	Paper	1932	2	150	450	582	11,200	670	3,870	34,000	8,400
Independent Oil & Gas Co., Kansas City, Kan.	Oil Ref.	1934	3	46.8	450	610	5,200	....	2,900	23,500	.....
Interlake Iron Corp., Federal Furnace Plant, S. Chicago	Iron & Coke	1928	4	50	400	650	6,400	....	3,300	24,400	.....
International Power & Paper Co., Dalhousie, N. B.	Paper	1930	4	90	425	680	13,000	800	.....	.....	.....
Lazote, Inc., Belle, W. Va.	.....	1928	3	...	450	500	6,140	....	.....	.....	.....
Magnolia Petroleum Co., Beaumont, Tex.	Oil Ref.	1929	4	150	425	650	15,020	....	11,700	18,000	6,720
Miami Copper Co., Miami, Ariz.	Copper	1930	4	63	420	660	7,200	396	4,200	17,000	.....
Michigan Limestone & Chem. Co., Rogers City	.....	1930	3	80	400	700	8,800	....	.....	.....	.....
Minnesota & Ont. Paper Co., Inter. Falls, Minn.	Paper	1928	3	...	450	700	10,000	.....	.....	.....	.....
National Cash Register Co., Dayton, O.	Business Mach.	1929	1	80	450	750	7,350	1,044	.....	.....	.....
National Electric Products Co., Economy, Pa.	.....	1926	1	...	425	550	7,380	....	.....	.....	.....
Nat. Enamelling & Stamp Co., Granite City, Ill.	Ceramic	....	..	...	435	625	.....	....	.....	.....	.....
Nekoosa-Edwards Paper Co., Port Edwards, Wis.	Paper	1929	2	100	407	600	9,110	1,900	6,500	20,000	.....
New Haven Pulp & Board Co., New Haven, Conn.	Paper	1929	1	84	400	600	7,600	370	.....	.....	1,639
Ninety-six Cotton Mills, Ninety-six, S. C.	Textile	....	..	...	400	550	.....	.....	.....	.....	.....
Oxford Paper Co., Rumford, Me.	Paper	1931	2	200	450	650	12,000	1,932	7,500	20,000	3,024
Paraffine Co., Inc., Emeryille, Calif.	.....	....	2	...	450	650	7,650	....	.....	36,000	.....
Pennsylvania Sugar Co., Phila., Pa.	Sugar Ref.	1932	2	250	400	500	11,000	6,530	10,400	.....	5,000
Phil. & Reading Coal & Iron Co., Maple Hill, Pa.	Coal Mining	1932	2	120	450	460	11,100	100	.....	.....	3,460
Pittsburgh Steel Co., Monessen, Pa.	Steel	1930	4	126	425	675	14,250	....	9,600	22,000	.....
Procter & Gamble Mfg. Co., Baltimore, Md.	.....	1929	3	60	450	700	5,530	198	2,320	34,000	.....
Proximity Mfg. Co., Greensboro, N. C.	.....	1928	2	90	450	650	8,630	1,740	6,500	19,800	.....
		1933	1	90	450	650	10,210	1,180	4,440	28,900	.....

Type of Firing Equipment: O., oil; G., gas; U.S., underfeed stoker; P.C., pulverized coal; L.G., link-grate stoker; C.G., chain-grate stoker; S.&L.F., stoker and liquid fuel; S., stoker; W.R., wood refuse; A.S., acid sludge; B.&G., coke breeze on chain-grate stokers and gas.

Type of Power Units: B.P., back-pressure turbine; B.T., bleeder-turbine; C.T., condensing turbine; C.E., compound engine; C.C.T., cross-compound turbine;

Industrial Steam Plants

Gas. Temp. Leaving Econ. Deg. F.	Air-Preheater Surface, Sq. Ft.	Air Temp. Leaving Preheater, Deg. F.	Forced-Draft Fans, No. per Boiler	Capacity F.-D. Fans, Ea. Cu. Ft.	Induced-Draft Fans, No. per Boiler	Capacity I.-D. Fans, Ea., Cu. Ft.	Final Feed-Water Temp., Deg. F.	Type of Firing Equipment	B.T.U. per Lb. of Fuel	Av. Boiler-Plant Eff., Per Cent	Evaporation per Lb. of Fuel	Power Unit Type	Number	Capacity, KW., Each	Throttle Pressure, Lb. per Sq. In., Gage	Throttle Temp., Deg. F.	Bleed Pressure, Lb. Per Sq. In., Gage	Exhaust Pressure, Lb. per Sq. In., Ab.
450	30,150	350	1	50,000	1	100,000	420	P.C.	13,800	....	....	C.E.	2	3,750	1,500	800(a)	...	80
444	23,100	444	..	.....	..	.....	380	P.C.	12,620	....	....	B.P.	1	10,000	....	....	...	250
676	64,800	387	4	50,000	2	210,000	437	P.C.&G.	13,500	86.5	....	V.C.T.	1	110,000	1,200	725(b)	...	0.5
...	23,400	...	..	.....	..	.....	...	P.C.	.....	....	....	B.P.	2	5,000	725	725	...	180
...	33,400	...	1	.....	1	.....	...	P.C.	.....	....	....	B.P.	1	7,500	725	725	200	115
500	14,000	320	1	40,400	1	102,500	363	O.&G.	.....	....	....	B.T.	1	5,500	675	700	235	150
												B.P.	1	9,375	600	750	...	190
...	47,740	550	1	100,000	1	175,000	360	P.C.	14,000	86.7	11.5	B.T.	1	9,375	175	480	65	30
												C.T.	1	1,875	15	255	...	1
561	33,200	364	1	101,000	1	195,000	365	O.&G.	17,500	77.3	12.11	B.P.	2	7,500	625	750	...	172
...	.....	...	..	.....	..	.....	...	A.S.&P.C.	....	....	....	....	1	7,500	625	750	...	.....
...	.....	...	..	.....	..	.....	...	....	.....	....	....	B.P.	1	3,000	585	700	...	130
...	15,200	315	1	.....	1	75,000	255	P.C.	13,400	87	10.4	B.P.	1	1,500	600	750	...	105
													1	3,000	600	750	...	85
...	.....	500	1	.....	1	.....	212	P.C.	13,800	85	9.8	B.P.	1	7,500(c)	575	750	180	35
...	40,000	500	2	98,500	2	144,000	212	P.C.	13,800	....	....	B.P.	1	5,000	575	750	...	195
...	.....	535	1	50,000	1	60,000	212	P.C.	13,900	81	9.4	B.P.	1	5,000(d)	575	750	180	35
650	.....	525	1	.....	1	.....	212	P.C.	14,600	83	9.6	B.T.	1	5,000	400	750	20	1
												B.P.	2	5,000(e)	400	750	150	35
...	40,000	525	2	98,500	2	144,000	212	P.C.	14,600	....	....	B.P.	1	7,500	575	750	400	35
...	11,600	450	1	50,000	1	110,000	350	P.C.	10,000	81	....	B.P.	2	3,750	475	600	140	20
...	.....	...	1	.....	..	.....	220	L.G.	12,000	72	8	....	..	....	...	...	...	.....
...	.....	...	..	.....	..	.....	...	G.	.....	....	....	B.P.	3	7,500	385	...	125	40
...	.....	...	1	28,000	..	.....	230	U.S.	14,500	76	9.4	B.P.	2	1,000	400	600	...	105
...	.....	...	..	.....	..	.....	...	P.C.	.....	....	....	B.T.	1	1,500	400	600	90	1.5
...	13,300	281	1	58,700	1	85,000	265	U.S.	13,500	76.8	10.3	B.P.	1	7,500	380	550	120	45
...	.....	...	1	11,000	..	.....	245	C.G.	9,900	79.3	7.7	....	..	....	...	...	...	.....
...	9,580	...	..	.....	1	140,000	216	P.C.	.....	83	10	B.T.	1	4,000	420	...	10	1
...	13,500	430	1	32,000	1	70,000	350	G.	.....	75	....	B.T.	1	4,000	425	710	25	1
..	17,700	525	1	50,000	1	78,000	350	O.&G.	.....	81	....	B.P.	1	7,500	425	710	150	40
								U.S.				....	..	....	...	...	...	.....
523	39,200	398	1	115,000	1	290,000	254	P.C.	13,140	87.6	10.1	B.T.	2	4,000	400	700	125	25
...	10,000	390	1	23,300	1	43,500	275	U.S.	14,500	....	....	B.T.	1	2,500	375	600	125	25
												C.T.	2	8,300	420	550	...	.....
...	.....	350	1	.....	1	.....	300	U.S.	14,800	....	....	B.P.	3	Total	420	550	...	.....
...	6,160	...	..	.....	..	.....	...	U.S.	13,500	81		B.P.	1	6,000	400	700	125	45
...	.....	...	1	20,000	0.5	56,000	308	O.&G.	18,500	81	....	B.T.	1	3,560	350	650	58	1
													1	1,000	375	625	...	25
350	.....	...	1	35,000	1	36,000	308	P.C.	14,600	84	10.53	B P.	1	1,500	375	625	...	25
													1	3,000	375	625	...	25
													1	4,000	375	625	...	25
...	.....	...	..	.....	..	.....	...	P.C.	.....	....	....	B.P.	1	5,000	385	600	...	25
...	4,000	...	1.5	.....	1	40,000	227	G.&P.C.	.....	....	....	B.T.	2	1,300	425	625	150	65
...	4,200	450	2	17,000	1	70,000	212	S.	14,350	....	10.8	B.T.	5	75–750	375	550	5	1
...	79,700	500	1	60,000	1	90,000	350	P.C.&O.	13,500	....	....	C.T.	1	10,000	350	700	150, 60, 10	2
383	68,800	292	2	59,000	2	82,500	220	P.C.&O.	13,500	....	....	B.P.	1	2,000	350	700	...	25
...	.....	...	..	.....	..	.....	...	P.C.	.....	....	....	B.T.	2	5,000	400	680	30	1
500	6,280	300	2	13,500	1	63,000	375	P.C.	14,200	83	10.7	B.T.	2	3,000	400	700	75	1
					1	.....	225	O.	.....	....	....	C.T.	1	750	160	...	2	0.5
...	.....	...	2	23,070	1	103,000	220	S.	14,000	....	10.5	....	..	....	...	...	...	.....
														300	...	...	...	1
...	6,500	390	1	28,500	1	55,000	260	P.C.	14,400	84.4	10.4	B.T.	3	2,000	425	630	100	1
														2,500	...	...	...	.....
												C.T.	2	1,000	375	600	...	1
...	.....	...	..	.....	1	46,000	...	C.G.	.....	....	....	B.P.	1	500	375	600	...	150
...	14,400	400	2	.....	1	.....	200	P.C.	14,200	80	....	B.T.	1	9,000	425	630	125	40
													1	9,000	425	630	25	1
...	.....	...	1	38,000	..	.....	...	P.C.	.....	....	....	B.T.	1	7,500	400	650	150	30
...	.....	...	..	.....	..	.....	370	P.C.	.....	....	....	B.T.	1	7,500	425	600	150	1
												C.C.T.	2	7,500	385	700	...	1.5
...	.....	...	..	.....	..	.....	....	G.&P.C.	.....	....	....	C.T.	2	(Drive 60,000 c.f.m. 30-lb. centrifugal blowers)				
...	19,300	470	1	53,000	1	96,500	275	P.C.	14,100	84.1	10.9	B.T.	1	7,500	415	650	7	1
													1	6,000	415	650	7	1
...	.....	...	1	49,000	1	104,000	...	U.S.	.....	....	....	B.P.	1	3,000	420	582	...	135
...	.....	...	..	.....	1	45,000	250	O.&G.	.....	....	....	....	..	....	...	...	...	.....
												B.T.	3	5,500	390	650	125	1
...	.....	...	0.75	30,000	..	.....	228	B.&G.	11,300	74.5	....	B.P.	3	350	390	650	...	16
												....	1	1,000	390	650	...	.....
...	11,900	350	1	.....	0.75	.....	230	P.C.	.....	....	....	B.P.	1	6,000	425	680	...	140
...	.....	...	..	.....	..	.....	...	P.C.	.....	....	....	C.T.	2	1,250	400	500	...	1
350	.....	...	2	40,000	1	110,000	350	O.&G.	18,000	80	....	B.P.	2	7,500	385	650	150	25
...	7,950	430	1	18,000	1	36,000	300	O.	18,000	83.2	....	B.T.	1	12,500	400	650	70	1.5
...	4,560	300	1	34,500	1	80,500	...	U.S.	13,500	....	....	B.T.	1	10,000	375	700	...	.....
...	.....	...	..	.....	..	.....	...	P.C.	.....	....	....	B.P.	2	8,000	425	700	135	25
...	.....	...	1	.....	..	.....	220	P.C.	14,400	72	8.5	B.T.	1	5,000	425	750	60	0.75
...	.....	...	..	.....	..	.....	...	U.S.	.....	....	....	B.P.	1	1,000	400	550	125	55
...	.....	...	..	.....	..	.....	...	....	.....	....	....	B.P.	1	1,000	425	625	...	155
												B.P.	1	2,200	385	600	...	165
...	11,000	320	1	30,000	1	50,000	300	P.C.	14,000	83	12.5	B.T.	1	1,500	150	415	10	1.5
												C.T.	1	1,250	150	415	...	1.5
450	.....	230	1	.....	1	.....	250	U.S.	14,300	85	10.9	B.T.	1	2,000	375	600	80	40
...	.....	...	..	.....	..	.....	...	....	.....	....	....	C.T.	1	2,000	245	554	...	1
475	13,220	323	1	47,400	1	70,300	280	P.C.	15,000	86	11.9	....	..	....	...	...	...	.....
...	12,200	...	1	83,500	1	88,000	...	O.	.....	....	....	B.T.	1	2,500	425	650	150	55
710	18,750	325	1	75,000	1	135,000	250	P.C.&O.	14,000	....	....	B.T.	1	2,500	400	500	90	25
471	.....	...	1	67,000	1	125,000	220	C.G.	13,000	70	8.3	5 Corliss engines 150 lb. pressure.						
...	.....	...	1	50,000	1	150,000	218	P.C.&G.	.....	80	....	....	..	....	...	...	...	.....
...	3,530	325	1	25,000	1	33,500	350	U.S.	13,300	....	....	B.P.	1	5,000	400	575	...	165
...	12,880	420	1	32,000	1	77,000	245	P.C.	13,800	....	....	B.P.	2	2,000	415	700	...	165
...	9,920	400	1	31,000	1	56,800	245	P.C.	13,800	....	....	....	1	2,500	...	...	...	.....
												....	1	3,500	400	650	...	1
												....	1	3,000	400	650	...	165

E., engine. V.C.T., vertical cross-compound turbine.

aEngines have three cylinders; exhaust from the intermediate cylinder is reheated to 526 deg. F. before going to the low-pressure cylinder.

bExhaust at 85 lb. from the high-pressure unit is reheated from 317 to 550 deg. F. before going to the low-pressure unit; c, superimposed on an 8,000-kw., 180-lb. plant; d, superimposed on a 5,000-kw., 180-lb. plant; e, superimposed on a 11,300-kw., 150-lb. plant.

High-Pressure Industrial Steam Plants—Continued

Company and Location	Kind of Industry	Initial Operation	No. of Boilers	Max. Cap., Each 1,000 Lb. per Hr	Gage Pressure, Lb. per Sq. In.	Steam Temp. Deg. F.	Boiler Heating Surface, Sq. Ft.	Water-Wall Surface, Sq. Ft.	Furnace Volume, Cu. Ft.	B.T.U. Liberated, Max., per Cu. Ft. per Hr.	Economizer Surface, Sq. Ft.
Rhinelander Paper Co., Rhinelander, Wis	Paper	1929	2	104	415	550	8,340	250	4,500	.....	5,184
			1	104	415	550	8,340	400	.....	.....	6,670
Seaboard Power Corp., Ltd., Sydney, N. S.	Steel & Coal	1930	2	20	430	642	9,219	1,610	.....	.....	.....
Howard Smith Paper Mills, Cornwall, Ont.	Paper	1929	1	96.4	400	450	8,480	1,061	5,360	.....	.....
Semet Solvay, Harriett, N. Y.	Chemical	1927	2	...	415	700	6,000	....	.....	.....	.....
The Sorg Paper Co., Middletown, O.	Paper	....	3	70	415	775	5,790	437	.....	.....	2,969
St. Croix Paper Co., Woodland, Me.	Paper	1931	1	100	450	725	7,430	1,296	8,070	15,050	3,120
St. Lawrence Paper Mills, Three Rivers, Que.	Paper	....	..	...	415	600	.....	.....	.....	.....	.....
Standard Oil Co. (Indiana) Whiting, Ind.	Oil Ref.	....	8	...	415	625	15,300	....	.....	.....	.....
Standard Oil Co. of N. J., Bayonne, N. J.	Oil Ref.	1926	2	...	400	700	12 000	....	.....	.....	.....
John Strange Paper Co., Menasha, Wis.	Paper	1929	3	...	400	600	6,000	....	.....	.....	.....
Taylor Instrument Co., Rochester, N. Y.	Instruments	1931	2	45.6	415	650	5,170	....	3,800	.....	.....
Tennessee Eastman Corp., Kingsport, Tenn.	Chemical	1931	6	65	450	575	8,700	....	2,500	35,400	.....
Tobacco By-Products Co., Louisville, Ky.	Insecticide	1928	2	...	425	625	2,500	....	.....	.....	.....
Vacuum Oil Co., Inc., Paulsboro, N. J.	Oil Ref.	1927	3	200	450	560	17,320	....	.....	.....	10,900
Viscose Co., Meadville, Pa.	Rayon	1929	3	...	450	650	10,800	....	.....	.....	.....
Western Electric Co., Inc., Baltimore, Md.	Electrical Manufacture	1930	1	57	450	...	13,050	420	8,250	25,700	.....
		1930	2	86	450	...	7,100	320	5,130	22,600	.....
West Vaco Chlorine Prod., Inc., S. Charlestown, W. Va.	Chemical	1927	5	90	400	660	7,150	....	.....	.....	.....
C. H. Wheeler Mfg., Co., Philadelphia, Pa.	Machinery	1927	1	...	425	Sat.	2,670	....	.....	.....	.....
Youngstown Sheet & Tube Co., Youngstown, O.	Steel	1930	6	180	415	700	20,280	....	20,500	12,500	.....
Pressures 300 Lb. to 399 Lb.											
Aberfoyle Mfg. Co., Chester, Pa.	.....	1927	2	...	300	425	7,500	....	.....	.....	2,700
American Enka Corp., Enka, N. C.	Textile	1929	4	38	350	650	5,070	....	1,400	.....	.....
		1934	1	90	350	675	8,200	1,230	4,170	20,000	.....
Appleton Company, Anderson, S. C.	.....	1934	..	...	300	550	.....	.....	.....	.....	.....
Bedford Pulp & Paper Co., Big Island, Va.	Paper	1930	3	70	385	560	695	344	.....	.....	4,320
Bergstrom Paper Co., Neenah, Wis.	Paper	1929	3	...	350	580	5,650	....	.....	.....	.....
Bryant Paper Co., Kalamazoo, Mich.	Paper	1923	3	...	300	600	7,780	....	.....	.....	.....
Canada Board Co., Ltd., Toronto, Ont.	Paper	1928	2	...	300	580	.....	....	.....	.....	.....
Canada Sugar Refining Co., Ltd., Montreal	Sugar	....	2	75	300	500	7,660	....	3,830	30,000	
Canadian Salt Co., Sarnia, Ont.	Salt	1926	2	...	350	710	7,000	....	.....	.....	.....
		1929	1	...	350	710	10,000	....	.....	.....	.....
Chicago University, Chicago, Ill.	Education	....	4	90	300	520	12,000	160	3,500	30,800	3,360
Colorado Fuel & Iron Co., Minnequa, Colo.	Steel	1926	7	85	330	640	12,000	....	.....	.....	.....
Container Corp., Cincinnati, O.	Paper	1932	2	...	350	600	9,160	....	.....	.....	.....
Dept. of Water Supply, Detroit, Mich.	Water	1934	2	90	380	710	10,388	510	4,125	29,127	2,430
Dept. of Public Works, Pittsburgh, Pa.	Water	1928	2	55	325	625	6,230	50	1,600	27,500	.....
Dow Chemical Co., Midland, Mich.	.....	1924	2	70	385	625	8,200	....	2,800	.....	.....
		1927	2	150	385	625	15,000	2,200	13,670	15,000	.....
		1929	1	170	385	625	15,000	2,300	13,670	17,000	.....
		....	1	190	385	625	17,700	1,900	11,650	22,000	.....
Eagle Paper Co., Joliet, Ill.	.....	1924	2	...	300	575	.....	....	.....	.....	.....
Garlock Packing Co., Palmyra, N. Y.	Packing	1928	2	45.5	380	525	5,050	....	.....	.....	.....
P. H. Glatfelter Co., Spring Grove, Pa.	Paper	1930	2	135	350	560	11,380	290	6,500	27,000	13,150
Glen Alden Coal Co., Nanticoke, Pa.	Coal	1925	7	55	300	550	6,675	144	.....	.....	3,275
Grays Harbor Pulp & Paper Co., Hoquiam, Wash.	Paper	1928	5	...	375	550	8,400	....	.....	.....	.....
Halltown Paper Board Co., Halltown, W. Va.	Paper	1928	2	...	300	500	4,000	....	.....	.....	.....
P. H. Hanes Knitting Co., Salem, N. C.	Textile	1928	2	40	300	590	4,930	....	.....	.....	.....
John H. Heald Co., Lynchburg, Va.	Paper	1929	3	90	325	522	10,440	1,009	.....	.....	.....
Howard Bend Pumping Sta., St. Louis, Mo.	Water	....	4	39	320	625	6,520	....	2,520	21,700	.....
Humble Oil & Refining Co., Ingleside, Tex.	Oil Ref.	1929	4	40	350	625	5,090	....	.....	.....	.....
Industrial Rayon Corp., Covington, Va.	Textile	1929	3	70	300	585	6,570	860	3,800	24,000	.....
Inland Steel Co., Indiana Harbor, Ind.	Steel	1925	9	...	300	625	.....	....	.....	.....	.....
Logan Long Co., Franklin, O.	Roofing	1933	1	40	300	570	5,900	....	1,730	33,000	.....
Marathon Paper Mills Co., Rothschild, Wis.	Paper	....	1	...	320	...	8,700	....	1,640	.....	5,700
Mead & Johnson, Evansville, Ind.	.....	1927	..	...	300	417	.....	....	.....	.....	.....
Murray Corp. of Am., Memphis, Tenn.	Wood Prod.	1930	3	50	300	515	7,500	....	6,400	.....	.....
National Paper Products Co., Pt. Townsend, Wash.	.....	.....	..	...	375	600	.....	....	.....	.....	.....
National Sugar Refining Co., L. I. C., N. Y.	Sugar	1929	5	180	325	500	12,000	700	5,760	40,000	.....
Packard Motor Car Co., Detroit, Mich.	Auto	1927	5	110	315	575	11,650	140	5,240	30,000	.....
Perry Knitting Co., Perry, N. Y.	Textile	1924	2	38	300	540	4,550	....	.....	.....	.....
Raritan Copper Works, Perth Amboy, N. J.	Copper	1926	3	120	385	650	12,000	....	8,900	13,700	6,100
Restigouche Co., Ltd., Athols, N. B.	Paper	1930	2	120	350	620	8,250	4,920	...	.....	4,200
			2	20	350	620	3,000	....	...	.....	.....
R. J. Reynolds Tobacco Co., Winston-Salem, N. C.	Tobacco	1926	4	45	385	644	4,860	....	.....	.....	.....
			2	100	385	644	10,800	....	.....	.....	2,980
Riverside Paper Corp., Appleton, Wis.	Paper	1928	2	40.8	300	750	4,075	....	... ..	... .	5,184
Sayles Biltmore Bleacheries, Inc., Biltmore, N. C.	Bleaching & Finishing	1926	2	40	300	535	4,772	70	....	.....	.....
Schutte & Koerting Co., Cornwells Hts., Pa.	.....	1926	2	...	350	Sat.	1,500	....	.....	.....	.....
Standard Oil Co., of N. J., Bayway, N. J.	Oil Ref.	1926	4		380	700					
Sunbury Converting Works, Belvidere, N. J.	Textile	1930	2	180	360	460	8,250	5,300	8,600	18,900	4,200
Tennessee Coal & Iron Co., Fairfield, Ala.	Steel	1928	5	175	375	650	14,610	1,210	12,500	16,400	10,600
		1932	1	300	375	650	20,840	3,610	16,400	21,400	12,050
Thunder Bay Paper Co., Port Arthur, Ont.	Paper	1926	2	...	385	660	10,140	....	.....	.....	2,300
Titanium Pigment Co., St. Louis, Mo.	Paint	1928	3	...	300	600	4,000	....	.....	.....	.....
Tubize Chattillon Corp., Rome, Ga.	Textile	1929	5	37.5	300	600	5,000	....	.....	.....	4,700
Western Electric Co., Inc., Kearny, N. J.	Electrical Manufacture	1925	4	71	300	650	8,000	....	1,640	83,000	.....
		1930	2	87	300	650	8,400	....	1,720	84,200	4,203
Weyerhauser Timber Co., Klamath Falls, Ore.	Lumber	1929	4	50	325	580	8,000	....	5,735	17,000	.....
Wilson & Co., Inc., Chicago, Ill.	Meat Packing	1934	3	140	380	550	11,200	1,570	10,200	16,000	4,830

Type of Firing Equipment: O., oil; G., gas; U.S., underfeed stoker; P.C., pulverized coal; L.G., link-grate stoker; C.G., chain-grate stoker; S.&L.F., stoker and liquid fuel; S., stoker; W.R., wood refuse; A.S., Acid Sludge; B. & G., coke breeze on chain-grate stokers and gas.

Gas. Temp. Leaving Econ. Deg. F.	Air-Preheater Surface, Sq. Ft.	Air Temp. Leaving Preheater, Deg. F.	Forced-Draft Fans, No. per Boiler	Capacity F.-D. Fans, Ea. Cu. Ft.	Induced-Draft Fans, No. per Boiler	Capacity I.-D. Fans, Ea., Cu. Ft.	Final Feed Water Temp., Deg. F.	Type of Firing Equipment	B.T.U. per Lb. of Fuel	Av. Boiler-Plant Eff., Per Cent	Evaporation per Lb. of Fuel	Power Unit Type	Number	Capacity, KW., Each	Throttle Pressure, Lb. per Sq. In., Gage	Throttle Temp., Deg. F.	Bleed Pressure, Lb. Per Sq. In., Gage	Exhaust Pressure, Lb. per Sq. In., Ab.
350	.....	...	2	.....	1	.....	360	U.S.	13,200	81	...	B.T.	2	6,000	400	550	125	15
...	.....	...	1	.....	..	.....	...	.....	.....	...	...	.....	..	.....	...	...	...	.....
...	5,000	380	1	35,000	1	70,000	302	P.C.	12,633	83.8	10.9	C.T.	1	6,500	407	642	...	1
...	9,900	390	1	30,000	1	56,400	212	P.C.	13,800	83.4	10.7	.....	..	.....	...	...	...	.....
...	.....	...	...	.....	..	.....	...	.....	.....	...	...	B.P.	1	1,500	400	700	...	160
340	7,350	285	1	11,300	1	22,600	...	P.C.&O.	14,300	84	10.2	B.T.	2	5,000	390	775	105	42
340	10,143	280	1	30,000	1	52,000	220	P.C.	14,680	88.2	11.52	B.P.	1	3,750	400	700	...	110
...	.....	...	...	.....	..	.....	...	.....	.....	...	...	B.P.	1	1,500	400	600	...	120
...	10,600	...	...	.....	..	.....	...	P.C.	.....	...	...	B.P.	3	5,000	400	625	...	125
...	.....	...	...	.....	..	.....	...	.....	.....	...	...	B.P.	1	2,500	365	680	...	115
...	.....	...	...	.....	..	.....	...	U.S.	.....	...	...	B.P.	1	2,500	385	600	125	15
...	.....	...	1	.....	1	.....	220	P.C.	14,500	82	11	B.P.	2	600	...	...	...	17
...	.....	...	0.8	30,000	..	.....	230	U.S.	14,500	80	10	B.T. C.T.	2 1	11,000 Total	400 400	575 575	90 90	30 1
...	.....	...	1	14,400	..	.....	225	U.S.	14,000	...	9.1	B.P.	1	300	400	625	...	120
400	.....	...	1	75,000	1	125,000	300	S.&L.F.	.....	82	...	B.P.	1	3,000	425	560	...	215
...	.....	...	...	.....	..	.....	...	P.C.	.....	...	...	C.T.	2	5,000	425	610	150	0.75
...	.....	...	1	54,000	..	.....	220	U.S.	13,500	...	9.9	.....	..	.....	...	...	...	.....
...	.....	...	1	30,000	..	.....	220	U.S.	13,500	...	...	.....	...	.....	...	...	...	.....
...	.....	...	1	.....	..	.....	230	U.S.	13,000	...	...	B.P.	1 1	2,500 7,500	375 375	660 660	...	25 25
...	.....	...	...	.....	..	.....	...	C.G.	.....	...	...	C.E.	2	.....	...	...	...	.....
...	20,100	...	1	184,000	1	198,000	350	P.C.&G.	.....	...	...	C.T.	2	18,000	385	700	...	3
...	10,000	...	...	.....	..	.....	...	P.C.	.....	...	...	B.P.	2	300	275	425	...	20
...	.....	...	0.5	55,000	..	.....	210	U.S.	13,800	72.5	8.5	B.T. B.P.	2 2	2,000 625	325	650	...	.....
...	7,700	360	1	25,000	1	52,000	210	P.C.	14,000	83.7	10	B.T.	1	3,000	325	650	...	.....
...	.....	...	...	.....	..	.....	...	.....	.....	...	...	B.T.	1	4,000	275	550	25	1
320	.....	...	...	.....	1	41,000	320	P.C.	14,500	83	10.1	.....	1	5,000	370	560	125	35
...	.....	...	...	.....	..	.....	...	U.S.	.....	...	...	B.T.	1	2,500	325	580	15	1
...	.....	...	...	.....	..	.....	...	U.S.	.....	...	...	B.P. B.P.	1 1	1,000 500	300 300	600 600	...	155 25
...	.....	...	...	.....	..	.....	...	U.S.	.....	...	...	B.T.	1	1,000	300	580	15	1
...	.....	520	1	30,000	1	46,000	235	P.C.	.....	80	...	B.P.	2	1,000	300	500	...	95
...	.....	...	...	.....	..	.....	...	P.C.	.....	...	...	B.P.	3	4,500	325	710	40	20
...	.....	...	...	.....	..	.....	...	P.C.	.....	...	...	.....	...	.....	...	...	...	.....
340	10,100	225	1	70,000	1	110,000	280	C.G.	12,000	...	...	.....	...	.....	...	...	...	.....
...	.....	...	1	35,000	1	40,000	200	P.C.&G.	.....	...	...	C.T.	3	10,000	300	640	100	2
...	.....	...	1	32,000	1	73,500	240	U.S.	.....	...	...	.....	...	.....	...	...	...	.....
466	9,980	312	1	45,000	1	75,000	288	U.S.	13,500	82	10.1	C.T.	2	5,000	350	700	...	0.5
...	5,570	235	1	18,000	1	48,000	210	U.S.	13,300	80	9.4	C.T. B.T. C.T. C.T.	1 1 1 1	450 900 200 4,000	300 300 300 350	600 600 600 600	... 40 ... 150	0.5 0.5 0.5 2
...	31,000	350	1	40,000	1	50,000	350	O.	19,000	...	...	C.E.	1	1,000	350	600	...	20
...	79,700	500	1	60,000	1	80,000	350	P.C.&O.	13,500	...	...	B.P.	1	5,000	350	600	...	165
...	68,700	500	1	60,000	1	80,000	350	P.C.&O.	13,500	...	...	B.P.	1	5,000	150	450	...	25
...	29,200	500	1	70,000	1	125,000	350	P.C.&O.	13,500	...	...	B.P.	1	5,000	350	600	...	165
...	.....	...	...	.....	..	.....	...	U.S.	.....	...	...	.....	...	.....	...	...	...	.....
...	.....	...	...	.....	..	.....	...	U.S.	.....	...	...	B.P. B.T.	1 1	500 300	285 285	575 575	... 15	15 1
...	.....	...	1	25,000	..	.....	275	U.S.	14,300	81	11.4	B.T.	1	1,000	370	525	50	1
360	.....	...	1	53,000	1	90,000	300	P.C.	14,300	87	10.9	B.T.	1	3,000	315	500	25	1
360	.....	...	1	30,000	..	.....	215	C.G.	.....	...	...	B.T.	1	12,500	275	550	4	0.5
...	.....	...	...	.....	..	.....	...	W.R.	.....	...	...	B.P. C.T.	2 1	7,500 7,500	375 375	550 550	... 140	155 0.5
...	.....	...	...	.....	..	.....	...	U.S.	.....	...	...	B.T.	2	750	300	500	30	1
...	.....	...	0.5	29,000	..	.....	...	U.S.	.....	83.5	...	B.T.	1	1,000	275	590	30	1.5
...	12,000	450	1	28,000	1	35,000	220	P.C.	14,500	80	12	B.P. B.P.	1 1	3,500 500	300 300	522 522	... ...	40 40
...	12,400	240	1	24,000	1	27,500	260	C.G	10,000	77	7	C.T. C.T. C.T. B.T.	2 1 1 2	3,000 360 720 300	300 300 300 300	610 610 610 610	 50	0.5 0.5 0.5 0.5
...	.....	...	0.25	50,000	0.5	160,000	212	G.	.....	...	...	B.T.	1	3,000	300	610	155	2
...	6,140	363	1	31,900	1	50,600	250	P.C.	14,200	83.5	11.4	B.T.	2	3,000	250	545	15	1.5
...	.....	...	...	.....	..	.....	...	P.C.&G.	.....	...	...	C.T.	11	.....	275	625	...	.....
...	.....	...	1	18,000	..	.....	...	U.S.	13,300	...	...	.....	..	.....	...	...	...	.....
325	.....	...	1	65,000	1	65,000	385	U.S.	13,800	83	...	.....	...	.....	...	...	...	.....
...	.....	...	...	.....	..	.....	...	C.G.	.....	...	...	B.T.	2	500	300	417	10	1
...	.....	...	0.66	54,000	..	.....	...	W.R.	.....	...	...	B.P.	3	1,000	275	515	....	30
...	.....	...	...	.....	..	.....	...	.....	.....	...	...	B.P.	1	500	350	600	...	125
...	123,000	400	1	76,000	1	119,000	216	U.S.	13,800	82.5	9.8	B.T.	1	2,500	285	500	50	25
...	.....	350	1	82,500	1	82,500	260	U.S.	13,800	83	...	C.T.	2	6,000	300	580	...	.....
...	.....	...	1	.....	..	.....	220	U.S.	13,800	...	8.9	B.T.	1	1,250	275	540	5	1
315	.....	...	2	35,000	1	78,500	325	P.C.	14,200	81	10.2	B.T.	1	3,000	365	650	165	1
...	10,000	250	1	48,200	1	.....	235	P.C.	12,530	84	9.4	B.T.	2	5,000	365	650	165	1
...	.....	...	...	.....	1	.....	235	W.R.	.....	...	...	B.T. C.T.	2 1	1,000 1,000	350 350	620 620	120 ...	45 1
...	.....	...	0.5	.....	1	.....	230	U.S.	14,500	78	...	E.	3	Total	...	...	...	.....
485	.....	...	0.5	.....	1	.....	230	U.S.	14,500	80	...	B.P.	2	6,500	375	385	10	25
360	.....	...	0.5	26,000	0.5	42,500	260	U.S.	13,000	82.1	8.1	B.T.	1	750	300	750	30	1
...	.....	...	0.5	10,000	..	.....	225	U.S.	14,000	77	...	B.T.	1 1	750 250	300 300	535 525	35 35	35 35
...	.....	...	...	.....	..	.....	...	O.	.....	...	...		1	125	350	Sat.	...	16
...	.....	...	...	.....	..	.....	...	A.S.&O.	.....	...	...	B.P.	2	4,000	360	700	...	115
310	12,000	225	1	.....	1	.....	206	P.C.	14,500	80	11.2	B.T.	2	1,250	350	450	110	45
456	10,640	337	1	60,000	1	120,000	350	P.C.&G.	12,000	83	10.25	C.T.	2	20,000	338	642	...	1
460	16,570	390	1	80,000	1	202,000	350	P.C.&G.	12,000	83	...	.....	...	.....	...	...	...	.....
...	8,500	...	...	.....	..	.....	...	U.S.	.....	...	...	C.T.	2	2,500	350	660	125	1
...	.....	325	...	.....	1	71,000	...	C.G.	11,500	...	8.9	B.P.	2	1,000	275	600	21	16
...	.....	...	...	.....	..	.....	212	U.S.	13,000	70	9	B.P.	1	2,500	285	550	15	1
...	.....	...	1	35,000	..	.....	212	C.G.	.....	...	...	B.T.	4	13,000	275	600	2	1
350	.....	...	1	42,000	1	75,000	310	C.G.	.....	...	...	B.T.	1	10,000	275	600	2	1
...	.....	...	...	.....	..	.....	210	W.R.	8,800	55	4.5	B.T.	1	5,000	300	580	125	1
527	13,800	365	1	49,000	1	70,400	324	P.C.	11,800	85	10.2	B.T.	1 1 1	1,500 2,000 2,500	380 380 380	550 550 550	155 155 155	100 25 25

Type of Power Units: B.P., back-pressure turbine; B.T., bleeder-turbine; C.T., condensing turbine; C.E., compound engine; C.C.T., cross-compound turbine; E. engine; V.C.T., vertical cross-compound turbine.

[a]Engines have three cylinders; exhaust from the intermediate cylinder is reheated to 526 deg. F.

Typical Industrial Steam Plants

Company Name and Location	Kind of Industry	Date of Initial Operation	No. of Boilers	Max. Cap. Ea., 1,000 Lb., Per Hr.	Gage Pressure Lb. Per Sq. In.	Steam Temp. Deg. F.	Boiler Heating Surface Sq. Ft.	Furnace Volume Cu. Ft.	Final Feed-Water Temp. Deg. F.	Type of Firing Equipment	Power Unit Type	Number	Capacity K.W.	Bleed Pressure, Lb. per Sq. In. Gage	Exhaust Pressure Lb. Per Sq. In. Ab.
Pressures Above 300 Lb.															
Canadian Nat'l. Railways, Montreal, Que.	R.R. Shops	....	2	100	350	550	10,150	....	212	P.C.	B.T.	1	1,000	160	25
											E.	2	Air compressors		
Consolidated W. Pr. & Paper Co., Port Arthur, Ont.	Paper	....	..	...	400	....	....	....	....	....	C.T.	1	2,500	110	0.5
Crane Co., Chicago, Ill.	.....	....	1	...	350	435	2,500	....	210	O.&G.	....	..	....	...	.....
Dominion Sugar Co., Wallaceburg, Ont.	Sugar	....	3	70	350	...	6,700	4,100	...	P.C.	....	..	....	...	.....
Howard Paper Co., Green Bay, Wis.	Paper	....	1	...	325	600	5,000	....	...	U.S.	B.T.	1	1,500	...	1
Inter. Comb. Tar & Chem. Co., Newark, N. J.	Chemical	1928	2	...	300	...	6,160	....	...	P.C.	....	..	....	...	.....
Penna. Salt Co., Wyandotte, Mich.	Salt	1928	1	...	450	600	12,450	....	...	P.C.	....	..	....	...	.....
Procter & Gamble, Long Beach, Calif.	Soap	....	3	...	450	600	.....	....	...	O.G.	B.P.	1	300	...	165
												1	600	...	165
Swift & Co., Chicago, Ill.	Food	....	5	100	300	...	11,100	....	...	C.G.	....	..	....	...	.....
U. S. Gypsum Co., Oakfield, N. Y.	.....	1925	3	...	325	...	5,000	....	...	....	B.P.	1	750	...	35
											B.P.	1	100	...	45
											B.P.	1	150	...	.....
Warren Mfg. Co., Milford, N. J.	.....	1928	2	...	385	550	5,100	....	...	P.C.	....	..	....	...	.....
Westinghouse Elec. & Mfg. Co., So. Phila., Pa.	Elec. Mfg.	1931	1	72	625	720	7,080	3,539	390	U.S.	B.P.	1	1,000	...	235
Westinghouse Elec. & Mfg. Co., Trafford, Pa.	Elec. Mfg.	1930	1	75	400	750	8,000	3,200	350	U.S.	B.P.	1	1,500	...	175
Pressures Below 300 Lb.															
Algonquin Printing Co., Fall River, Mass.	Textile	1929	6	18	200	490	3,000	....	210	O.	B.P.	1	750	...	30
											B.P.	1	150	...	30
											B.P.	1	37.5	...	30
American Bemberg, Elizabethton, Tenn.	Rayon	1928	3	36	250	535	4,000	750	...	U.S.	B.T.	1	1,500	7	1
			3	57	250	535	6,400	1,360	...	U.S.	B.P.	2	750	...	22
American Chicle Co., Long Island City, N.Y.	Chewing Gum	1920	..	...	...	....	....	....	...	....	B.T.	1	350	35	1
		1933	3	22	190	Sat.	6,000	....	200	S.	B.T.	1	350	35	20
											B.P.	1	220	...	20
											B.P.	1	130	...	20
American Glanzstoff Corp., Elizabethton, Tenn.	Rayon	1928	4	70	250	550	8,400	....	...	U.S.	B.T.	2	3,000	12	16
		1929	2	70	250	550	8,400	....	...	U.S.	B.T.	1	6,000	12	16
American Thread Co., Willimantic, Conn.	Textile	1930	3	50	225	...	6,570	....	...	P.C.	....	..	....	...	.....
Armour & Co., West Fargo, N. D.	Food	1932	1	60	150	Sat.	6,150	370	210	P.C.	E.	2	484	...	20
Atlantic Wire Co., Branford, Conn.	Wire	1929	2	...	170	Sat.	1,800	....	...	S.	E.	1	300	...	20
Atlas Brewing Co., Chicago, Ill.	Brewery	....	2	...	125	Sat.	6,000	....	180	C.G.	E.	1	200	...	20
Atwater Kent Mfg. Co., Phila., Pa.	Radio	1929	3	82	200	490	7,200	5,800	250	P.C.	B.T.	1	1,000	...	60
Austin Mfg. Co., Harvey, Ill.	Rd. Mach.	1928	2	25	200	Sat.	5,200	1,000	212	C.G.	B.T.	1	500	3	1.5
											C.T.	1	200	...	1.5
											E.	1	100	...	16.5
Beech-Nut Packing Co., Rochester, N. Y.	Food	1930	3	39	125	Sat.	4,370	3,300	212	P.C.	E.	1	80	...	.....
Beloit Iron Works, Beloit, Wis.	Metal	1933	2	15	250	485	5,100	....	...	C.G.	B.T.	2	700	8.5	1.5
Boston & Maine Ry., Boston, Mass.	Railway	1930	3	56	250	585	7,500	....	220	P.C.	E.	2	Air Compressors		
Bowman Dairy Co., Chicago, Ill.	Milk	1930	2	15	140	Sat.	2,630	....	...	O.	(Milk Treating Plant)				
Brown Co., Berlin, N. H.	Paper	....	1	120	200	568	10,000	7,600	...	P.C.	....	..	....	...	.....
Brown Paper Mill Co., Monroe, La.	Paper	1927	4	...	200	475	8,600	....	...	G.	B.T.	1	3,000	25	1.5
			3	...	200	475	5,000	....	...	W.R.	B.T.	1	6,000	40	1.5
Brunswick Laundry, Jersey City, N. J.	Laundry	1932	2	30	115	347	5,100	1,140	...	U.S.	E.	1	700	...	20
			2	27	115	347	4,500	1,140	...	U.S.	E.	1	250	...	20
											E.	1	150	...	20
											E.	1	300	...	17
Budd Wheel Co., Detroit, Mich.	Auto	1927	2	130	125	Sat.	12,500	4,200	...	U.S.	E.	1	200	...	17
		1928	3	...	150	Sat.	3,000	1,600	...	P.C.	E.	1	100	...	17
California State Prison, San Quentin, Calif.	Prison	1933	1	21	125	350	2,700	850	180	O.	E.	2	50	...	20
Canfield Oil Co., Cleveland, Ohio.	Oil Ref.	1928	2	25	150	475	4,100	1,000	212	S.&L.F.	....	..	....	...	.....
Canfield Oil Co., Coraopolis, Pa.	Oil Ref.	1929	3	18	105	460	3,500	600	212	U.S.	....	..	....	...	.....
Caron Spinning Co., Rochelle, Ill.	Textile	1931	1	23	150	500	3,000	2,200	...	P.C.	....	..	....	...	.....
Cashman Laundry, New York City.	Laundry	1931	2	50	150	Sat.	4,400	....	...	O.	E.	2	175	...	20
Chase Brass & Copper Co., Euclid, Ohio.	Metal	1932	3	38	200	540	5,000	....	215	U.S.	....	..	....	...	.....
Chevrolet Motor Co., Detroit, Mich.	Auto	1928	6	...	165	...	8,250	....	212	U.S.	....	..	....	...	.....
			1	...	165	...	12,500	....	212	U.S.	M.P.	3	3,500	...	1.5
Chicago Union Station Co., Chicago, Ill.	Heating	1932	4	140	200	Sat.	12,000	4,100	...	S.	....	..	....	...	.....
Cincinnati Union Terminal Co.	Heating	....	3	100	225	Sat.	10,000	....	....	U.S.	....	..	....	...	.....
City Hospital, Indianapolis, Ind.	Hospital	1930	3	35	160	Sat.	5,000	3,500	215	C.G.	B.P.	2	600	...	20
City Water Co., Chattanooga, Tenn.	Water	....	3	36	250	535	10,500	6,340	208	U.S.	C.T.	3	Pumping	...	1
											C.E.	5	Pumping	...	1
Claridge Hotel, Atlantic City, N. J.	Hotel	1932	3	...	175	378	2,000	4,200	208	H.S.	E.	3	200	...	18
Columbia Mills, West Pullman, Ill.	.....	1931	1	70	175	Sat.	.....	....	...	P.C.	....	..	....	...	.....
Container Corp. of Amer., Cincinnati, Ohio.	.....	1933	1	84	175	477	9,200	....	...	U.S.	....	..	....	...	.....
Cornell Medical College Asso., N. Y. C.	Hospital	1932	4	48	200	Sat.	8,000	....	...	O.	E.	3	1,550	...	16
Dewey Portland Cement Co., Davenport, Iowa.	Cement	1927	3	21	225	550	9,200	....	200	W.H.	C.T.	3	1,500	...	1
		1927	1	10	225	550	4,000	....	...	....	....	..	....	...	.....
Diamond Match Co.' Barberton, Ohio.	Match	1934	2	30	225	Sat.	.....	....	...	P.C.	....	..	....	...	.....
Eastern State Hospital, Williamsburg, Va.	Hospital	1933	2	...	125	Sat.	2,500	600	...	U.S.	E.	1	75	...	20
Elizabethtown Con. Gas Co., Elizabethtown, N. J.	Gas	1933	4	88	200	Sat.	5,000	....	225	C.G.	....	..	....	...	.....
Emery Industries, Inc., St. Bernard, Ohio.	Abrasives	1931	2	100	290	520	5,500	3,300	...	P.C.	B.T.	2	200	115	20
Fitchburg Paper Co., Fitchburg, Mass.	Paper	....	1	60	250	550	10,000	7,100	...	P.C.	....	..	....	...	.....
			1	90	250	550	12,000	8,000	...	....	....	..	....	...	.....
Fletcher-Thompson, Inc., Bridgeport, Conn.	Hat	1929	2	24	225	525	3,850	....	...	U.S.	B.P.	2	500	...	35
Ford Motor Co., Dearborn, Mich.	Auto	1931	6	500	250	650	29,460	22,000	240	P.C.	C.T.	3	30,000	...	0.5
Forstman Woolen Co., Clifton, N. J.	Textile	1932	3	60	250	506	4,600	3,150	280	P.C.	B.T.	1	1,250	35	1
											C.T.	1	750	...	1
											C.T.	1	300	...	1
Freeport Sulphur Co., Grande Ecaille, La.	Sulphur	1933	6	52	225	397	8,600	4,230	220	O.	B.P.	3	750	...	20
General Steel Castings Corp., Phila, Pa.	Metal	1930	2	...	150	...	7,200	4,600	...	P.C.	....	..	....	...	.....
Glenlyon Print Works, Phillipsdale, R. I.	Textile	....	3	50	175	500	8,000	....	...	P.C.	B.T.	1	1,000	115	1.5
											C.T.	1	600	...	1.5
											B.P.	2	500	...	25
Great Northern Ry. Co., Great Falls, Mont.	Railroad	1931	3	37	250	Sat.	3,500	2,650	214	P.C.	....	..	....	...	.....
Great Northern Ry. Co., Whitefish, Mont.	Railroad	1931	3	29	250	Sat.	2,750	2,650	213	P.C.	B.P.	1	300	...	20
											B.P.	1	200	...	20
Great Northern Ry. Co., Williston, N. D.	Railroad	1931	3	19	250	Sat.	2,500	860	15	C.G.	B.P	1	200	...	20
											B.P.	1	300	...	20
Great Western Sugar Co., Billings, Mont.	Sugar	1933	1	...	160	370	9,800	280	...	C.G.	B.P.	1	1,500	...	.....
Harlem Hospital, New York City.	Hospital	1933	4	...	175	Sat.	3,400	....	...	O.	E.	2	250	...	20
											E.	1	100	...	20
Harriman Co., Harriman, Tenn.	Paper	1929	3	...	250	...	5,000	....	...	U.S.	B.T.	1	1,500	30	20
											B.P.	1	250	...	20
Harvard Medical School, Boston.	Education	1931	2	100	250	500	6,100	4,400	...	P.C.	B.P.	1	1,000	...	20
Edward Hines Lumber Co., Burns, Ore.	Lumber	1929	4	69	250	550	8,000	....	220	W.R.	C.T.	2	3,000	...	1

Typical Industrial Steam Plants (Continued)

Company Name and Location	Kind of Industry	Date of Initial Operation	No. of Boilers	Max. Cap. Ea., 1,000 Lb., Per Hr.	Gage Pressure Lb. Per Sq. In.	Steam Temp. Deg. F.	Boiler Heating Surface Sq. Ft.	Furnace Volume Cu. Ft.	Final Feed-Water Temp. Deg. F.	Type of Firing Equipment	Power Unit Type	Number	Capacity K.W.	Bleed Pressure, Lb. per Sq. In. Gage	Exhaust Pressure Lb. Per Sq. In. Ab.
Hotel New Yorker, New York City	Hotel	1929	4	...	175	475	6,500	3,700	...	P.C.	E.	3	600	...	17
											E.	1	400	...	17
											E.	1	200 drives ref. mach.		
Illinois Glass Co., Gas City, Ind.	Glass	1928	2	...	150	Sat.	4,900	....	220	C.G.	Steam drives air comp. & pumps				
Inter. Business Machine Corp., Endicott, N. Y.	.....	1933	1	83	250	560	8,000	2,700	...	U.S.	E.	1	500	...	20
Inter. Power & Paper Co., Gatineau, Que.	Paper	1931	4	136	200	450	13,400	6,600	...	P.C.	...	..	...	...	.....
Iowa State Teachers College, Cedar Falls, Ia.	Education	1931	2	30	150	Sat.	....	....	...	C.G.	B.P.	1	625	...	20
Jewel Ridge Coal Corp. Richlands, Va.	Coal	1933	2	18	250	550	3,000	....	...	U.S.	C.T.	2	1,000	...	1
Kalamazoo Vegetable Parchment Co., Mich.	Paper	1934	1	150	250	650	10,500	7,500	225	P.C.	...	..	...	...	.....
Knickerbocker Laundry, Long Island City, N. Y.	Laundry	1931	2	50	200	Sat.	4,000	....	...	O.	E.	1	200	...	20
Kropp Forge Co., Chicago, Ill.	Metal	1929	..	...	Waste-heat boilers			....	...	....	M.P.	2	500	...	1.5
Long Island College Hospital, Bklyn, N. Y.	Hospital	1931	3	17	125	Sat.	2,750	....	200	S.	E.	1	300	...	20
											E.	1	150	...	20
Longview Fibre Co., Longview, Wash.	Paper	1927	3	...	190	525	8,300	....	...	W.R.	B.T.	1	2,500	...	1.5
			3	...	190	525	5,700	....	...	W.H.&O.	...	..	...	...	.....
Longview Hospital, Cincinnati, Ohio.	Hospital	1932	4	22	200	Sat.	3,100	1,000	180	U.S.	E.	2	200	...	22
											E.	1	150	...	22
Lorraine Mfg. Co., Pawtucket, R. I.	Textile	1928	3	60	200	520	7,370	3,900	...	O.	B.T.	1	3,000	10	1.5
											B.T.	1	1,500	10	1.5
Lynchburg Fdry. Co., Radford, Va.	Foundry	1932	2	15	175	425	2,200	1,400	210	P.C.	E.	1	600	...	16
											L.P.	1	1,000	...	1
R. H. Macy & Co., New York City	Dept. Store	....	11	...	140	Sat.	30,000 total	....	215	O.	E.	2	750	...	16
											E.	4	400	...	16
											E.	1	250	...	16
											L.P.	2	300	...	1
Mengel Co., Louisville, Ky.	Wood Work	1928	2	75	200	486	8,600	5,000	210	P.C.	B.P.	1	2,000	...	25
										&W.R.	B.P.	1	1,000	...	25
Milwaukee Chair Co., Milwaukee, Wis.	Furniture	1930	2	18	160	364	3,000	7,200	220	U.S.	E.	1	150	...	20
											E.	1	75	...	20
											E.	1	500	...	20
Montgomery Ward & Co., St. Paul, Minn.	Merchandise	1929	3	...	...	...	3,500	....	...	U. S.	E.	1	300	...	20
											E.	1	200	...	20
Murray Corp. of Am., Detroit, Mich.	Auto	1925	2	...	...	...	7,500	....	...	S.	.....	..	....	...	.....
		1930	2	10	...	...	10,000	7,300	...	P.C.	....	..	....	...	.....
Nashua River Paper Co., E. Pepperell, Mass.	Paper	1927	2	30	150	425	1,150	5,500	214	P.C.	E.	5	...	...	20
New City Hospital, Springfield, Ohio.	Hospital	1932	3	...	160	Sat.	2,500	....	...	U.S.	E.	2	300	...	17
New York City's Prison, Rikers Is., N. Y.	Prison	1934	4	38	200	...	5,100	....	...	U.S.	E.	3	500	...	27
Newton Pumping Sta., Newton, Mass.	Water	1933	2	10	240	550	2,500	1,100	240	P.C.	B.T.	1	450	...	0.5
											B.T.	1	580	...	0.5
											B.T.	1	750	...	0.5
Ninety-Six Cotton Mills, Ninety-Six, N. C.	Textile	....	3	...	250	550	4,000	....	...	U.S.	C.T.	1	2,000	...	
Notre Dame University, Notre Dame, Ind.	Education	1932	4	38	135	350	4,000	1,400	213	C.G.	...	..	...	...	.....
Ontario Refining Co., Ltd., Copper Cliff, Ont.	Copper	1930	6	40	175	500	6,500	2,120	220	W.H.	B.P.	1	2,500	...	25
		1930	1	75	175	500	10,000	7,740	225	P.C.	...	..	...	...	.....
Otis Elevator Co., Yonkers, N. Y.	Elevators	1929	3	...	260	560	6,000	3,600	210	P.C.	B.P.	1	1,500	...	16
											B.P.	1	1,000	...	16
Pennsylvania Ry. Co., Philadelphia, Pa.	Railroad	1929	2	275	275	Sat.	26,200	13,000	212	U.S.	B.P.	2	1,750	...	20
Penna. State College, State College, Pa.	Education	1930	4	40	250	525	6,150	1,360	235	U.S.	B.P.	1	1,250	...	27
											B.P.	1	750	...	27
Pilgrim State Hospital, Brentwood, N. Y.	Hospital	1932	4	60	150	Sat.	10,000	4,400	210	U.S.	E.	2	1,500	...	20
											E.	1	600	...	20
Purdue University, Lafayette, Ind.	Education	1925	4	...	200	480	5,000	....	220	U.S.	C.T.	2	500	...	1.5
		1933	2	45	200	530	6,500	2,700	220	U.S.	B.T.	1	2,500	25	1.5
Queens General Hospital, N. Y. City.	Hospital	1933	4	23	175	Sat.	3,800	1,700	212	O.	E.	2	250	...	20
											E.	1	100	...	20
Royal York Hotel, Toronto, Ont.	Hotel	1929	..	...	180	...	Steam Purchased		...	....	E.	3	400	...	18
											E.	1	150	...	20
Royal Victoria Hospital, Montreal, Que.	Hospital	1930	3	27	175	Sat.	4,500	500	...	C.G.	E.	1	100	...	20
											E.	1	75	...	20
Savannah Sugar Refining Corp., Savannah, Ga.	Sugar	1927	2	60	225	Sat.	9,600	1,200	235	O.	B.P.	1	1,200	...	25
W. F. Schrafft & Sons, Boston, Mass.	Confectionery	....	2	30	230	...	5,000	....	...	O.	T.	1	1,000 Five turb. drive		
											T.	1	750 ref. mach.		
Scribner Press Building, New York City.	Publishing	....	4	12	130	Sat.	2,600	....	210		E.	1	300	...	17.5
											E.	2	250	...	17.5
											E.	1	150	...	17.5
											E.	1	50	...	17.5
Shelby Cotton Mills, Shelby, N. C.	Textile	1933	2	36	250	505	6,500	....	...	U.S.	B.P.	1	1,200	...	16
Shell Petroleum Corp., Houston, Texas.	Oil Ref.	1929	5	...	250	...	5,500	....	...	O.G.P.	...	..	...	...	.....
State Teachers College, E. Stroudsburg, Pa.	Education	1931	2	28	125	Sat.	3,300	....	205	C.G.	Heating Plant		....	...	.....
Taunton State Hospital, Taunton, Mass.	Hospital	1931	2	20	165	Sat.	.....	....	...	S.	E.	3	75	...	2
Tennessee Paper Co., Chattanooga, Tenn.	Paper	1927	2	...	175	...	3,600	....	212	P.C.	E.	2	500	...	2
			1	...	175	...	5,800	....	212	P.C.	E.	1	Drives Beaters		50
Texas Gulf Sulphur Co., Newgulf, Texas.	Sulphur	....	10	...	225	Sat.	15,000	....	...	G.	B.P.	1	1,500	...	20
											B.P.	2	750	...	35
U. S. Bureau of Standards, Washington, D. C.	.....	1929	2	30	195	487	5,000	3,500	212	P.C.	B.T.	1	750	3	1.5
			2	20	195	487	3,400	2,400	212	P.C.	....	..	....	...	.....
U. S. Marine Hospital, Seattle, Wash.	Hospital	1932	3	...	100	Sat.	1,500	1,000	...	O.	...	..	...	...	.....
U. S. Pacific Coast Torpedo Sta., Keyport, Wash.	.....	1933	2	15	150	366	5,000	....	212	O.	C.T.	1	100	...	
											C.T.	1	500	...	
U. S. Rubber Co., Detroit, Mich.	Rubber	1927	2	120	200	550	.....	....	210	P.C.	...	..	...	...	.....
U. S. Soldiers Homes, Washington, D. C.	.....	1933	4	18	160	510	3,000	1,140	210	O.	B.P.	1	500	...	20
											B.P.	2	300	...	20
University of Iowa, Iowa City, Ia.	Education	1927	7	30	175	475	6,100	....	...	S.	B.T.	2	1,000	20	1
University of Nebraska, Lincoln, Neb.	Education	1929	4	70	250	556	8,100	2,100	250	U.S.	B.T.	2	1,250	55	0.5
Vassar College, Poughkeepsie, N. Y.	Education	1931	5	36	125	Sat.	5,600	....	190	U.S.	C.T.	1	300	...	5
The Viscose Co., Parkersburg, W. Va.	Rayon	1926	4	120	250	580	10,000	4,200	220	U.S.	B.T.	2	8,000	15	20
		1930	1	120	250	580	10,000	5,800	220	P.C.	B.T.	2	7,000	15	20
		1933	1	120	250	580	10,000	5,800	220	P.C.	B.T.	1	1,500	15	20
Western Electric Co., Hawthorne, Ill.	Elec. Mfg.	1924	2	48	160	470	6,500	2,000	210	C.G.	C.T.	3	5,000	...	
		1930	8	54	160	470	7,200	2,000	210	C.G.	B.T.	1	1,500	2	
		1931	4	70	160	470	7,200	2,000	210	C.G.	B.T.	1	3,000	2	
											C.T.	2	7,500	...	1
W. J. Whittal Asso., Worcester, Mass.	Rug. Mfg.	1930	3	50	200	488	5,100	1,500	269	U.S.	B.T.	1	1,500	20	0.5
											B.T.	1	300	20	0.5
William Wilheim, Passaic, N. J.	Textile	1929	2	53	175	Sat.	5,300	700	210	C.G.	B.T.	2	300	...	60
World Cleaners & Dyers, Mt. Vernon, N. Y.	Cleaning & Dyeing	1931	2	19	165	Sat.	2,600	....	...	O.	E.	1	750	...	35
											E.	1	100	...	35
Wurlitzer Mfg. Co., N. Tonawanda, N. Y.	Music	1929	1	...	250	...	4,600	3,230	...	W.R. & P.C.	....	..	....	...	.....

Type of Firing Equipment: O. & G., oil and gas; U.S., underfeed stoker; P.C., pulverized coal; C.G., chain-grate stoker; S. & L.F., stoker and liquid fuel; H.S., hand stoker; W.R., wood refuse; O.G.P., oil sludge, gas, pulv. petrol. coke; W.H., waste heat.
Type of Power Units: B.P., back-pressure turbine; B.T., bleeder turbine; C.T., condensing turbine; C.E., compound engine; L.P., low-pressure turbine; M.P., mixed-pressure turbine; E., engine; T., turbine.

Data for Installations of 400 Lb. Pressure and Above

Compiled by F. A. Annett
Associate Editor

Company Name and Location	Plant Name	Initial Operation	No. Boilers	Max. Cap. Each, 1,000 Lb. per Hr.	Gage Pressure Lb. per Sq. In.	Steam Temp., Deg. F.	Boiler Heating Sur., 1,000 Sq. Ft.	Water-Wall Surface, Sq. Ft.	Furnace Volume, 1,000 Cu. Ft.	1,000 B.t.u. Lib., M., per Cu. Ft. per Hr.	Economizer Sur. 1,000 Sq. Ft.	Gas Temp. Leav., Econ. Deg. F.
1200 Lb. Boiler Pressure and Above												
Edison Electric Illum. Co. of Boston, Mass	Edgar	1925	1	143	1,200	708	15.6	....	7.6	26.5	11.5	404
			2	250	1,400	750	15.1	1,235	10	35.4	5.6	355
			2	250	1,400	750	7	1,206	10.5	33.7	9.6	352
Deepwater Operating Co., Penns Grove, N. J.	Deepwater	1930	4	331	1,250	725	54	2,502	19.1	22.6	18.3	320
			2	290	....	....	....	2,139	....	....	4.8	....
Houston Lt. &Pr. Co., Houston, Tex	Deepwater	1924	2	350	1,365	850	7.8	1,473	13.5	35	13.8	510
Jersey Central Pr. & Lt. Co., So. Amboy, N. J	South Amboy	1930	3	280	1,400	750	7.2	2,036	12.9	27.5	4.4	647
Kansas City Pr. & Lt. Co., Kansas City, Mo	Northeast	1929	2	230	1,400	725	17	3,050	15.6	21	10.9	450
Milwaukee Elec. Ry. &Lt. Co., St. Francis, Wis	Lakeside	1926	4	300	1,300	725	23.6	5,205	28.6	14.9	...	...
Milwaukee Electric. Ry. & Lt. Co., E. Port Wash	Port Washington	....	1	690	1,320	825	44.1	7,710	58	15.2	....	....
New Jersey Pr. & Lt. Co., Holland, N. J	Gilbert	1930	2	250	1,400	743	7.9	2,194	18.1	20.2	11.9	582
Pacific Gas & Elec. Co., San Francisco, Cal	Station "A"	1931	1	500	1,350	750	10.7	1,617	15.1	37.9	21.1	687
			2	Reheat	....	....	....	....	....	43.3	17.9	701
San Antonio Pub. Ser. Co., San Antonio, Tex	Station "B"	1930	1	215	1,518	810	5	1,011	7	40	11.9	579
700 to 500 Lb. Boiler Pressure												
Kansas City Pr. & Lt. Co., Kansas City, Mo	Grand Ave.	1929	4	230	700	750	15.2	2,250	8.6	50	9.2	480
			1	....	....	....	....	....	6.5	....	....	....
Northern Indiana Pub. Ser., Michigan City, Ind	Michigan City	1931	3	345	700	775	7.9	2,250	14.7	31.8	14.9	600
Public Ser. El. & Gas Co., Burlington, N. J	Burlington	1932	1	600	730	860	30.3	4,816	25.9	30	....	....
Chicago Dist. Elec. Gen. Corp., Hammond, Ind	State Line	1929	6	450	670	740	10.3	3,900	21	26	19.8	560
			12	150	600	750	16.6	....	6	30	11.1	350
			3	Reheat Boilers		....	....	....	....	....	....	....
Commonwealth Edison Co., Chicago, Ill	Crawford	1924	5	200	600	750	17.3	1,253 / 2,813	5.8	40	7.4	350
		....	6	200	600	750	17.3	1,386	5.8	40	7.4	350
		....	6	200	600	750	17.3	1,786	5.8	40	6.9	350
Indiana & Michigan El. Co., Mishawaka, Ind	Twin Branch	1925	8	150	650	750	94.6	....	5.1	25.6	8.8	380
Iowa-Nebraska Lt. & Pr. Co., Lincoln, Neb	K. St. Station	1930	2	140	600	740	10.5	727	5.8	33.8	3.8	474
Louisiana St. Products, Inc., Baton Rouge, La	Louisiana	1930	5	364	640	750	13.8	1,843	16.9	31.4	9.8	638
Ohio Power Co., Philo, O	Philo	1924	8	135	650	750	94.6	....	5.4	....	8.8	345
		1929	2	125	650	750	95.6	1,597	8.3	50	15.8	....
		....	4	275	....	....	....	....	....	....	....	....
		....	2	350	650	750	43.1	3,022	15.2	....	....	....
Potomac Elec. Pr. Co., Washington, D. C	Buzzard Point	1933	2	375	670	835	5.5	3,125	12.1	38.5	11.1	667
Public Ser. Co. of Northern Ill., Waukegan, Ill	Waukegan	1927	4	185	650	725	14.4	....	....	....	7.1	410
		1930	3	300	650	750	6.2	2,900	....	....	17.2	480
		1931	3	500	650	750	10	3,810	....	....	28.6	650
Stanton Operating Co., Pittston, Pa	Stanton	1927	8	175	675	725	119.7	....	7.8	43	3	280
Union Gas & Elec. Co., Columbia Park, O	Columbia	1925	8	200	635	730	15.1	425	12.9	21	7.2	410
Wisconsin Pr. & Lt. Co., Sheboygan, Wis	Edgewater	1931	2	300	650	825	5.4	2,724	10.3	40	14.8	458
Buffalo General El. Co., Tonawanda, N. Y	Huntley No. 2	1930	4	600	500	750	36.8	3,301	22.9	34	....	....
Virginia Public Service, Bremo Bluff, Va	Bremo	1931	2	200	525	825	19.8	1,838	9.4	25.6	16	325
400 Lb. Boiler Pressure												
Alabama Power Co., Gorgas, Ala	Gorgas Unit 4	1929	2	450	475	725	30.3	3,587	24.7	22	....	....
Brooklyn Edison Co., Inc., Brooklyn, N. Y	[1]Hudson Ave.	1926	4	290	415	700	22.9	1,540	....	....	....	....
		1928	8	350	415	720	23.8	1,322	....	....	15	340
		1932	8	530	415	740	24.5	3,846	....	....	22.4	375
Cambridge El. Lt. Co., Cambridge, Mass	Cambridge	1930	2	150	448	665	14.3	669	5.5	36	12.7	354
Central Ariz. Lt. & Pr. Co., Phoenix, Ariz	....	1930	2	150	400	725	12.2	1,150	8.9	20	7.1	350
Central Illinois Lt. Co., Peoria, Ill	East Peoria	1925	4	170	406	700	13.9	1,280	14.4	17	8.5	425
Cleveland Elec. Illum. Co., Ashtabula, O	Ashtabula	1930	6	416	400	725	32.6	....	32.6	18.7	23.2	315
Cleveland Elec. Illum. Co., Avon, O	Avon	1926	8	340	400	725	30.6	....	30.6	15.5	21.1	275
Consolidated Gas El. Lt. & Pr. Co., Baltimore	Gould St.	1927	2	500	440	735	26.4	3,737	21	31	....	....
Consumers Power Co., Kalamazoo, Mich	Kalamazoo	1927	3	150	400	725	15.4	1,770	8.3	24.8	....	....
Detroit Edison Co., Detroit, Mich	Delray No. 3	1929	5	340	400	725	23.9	2,044	13.8	35	6	500
Detroit Edison Co., Trenton, Mich	Trenton Channel	1924	13	360	400	725	29.1	1,220	25	18	19	300
El Paso Electric Co., El Paso, Tex	Rio Grande	1929	2	185	450	750	15.3	1,249	8.8	28.3	....	....
Florida Public Service Co., Avon Park, Fla	Avon Park	1928	2	140	448	713	13.1	....	8.1	24.4	7.8	340
Georgia Power Co., Atlanta, Ga	Atkinson	1930	2	450	465	750	30.2	3,580	25.1	17	....	....
Gulf States Utilities Co., Beaumont, Tex	Neches	1926	4	215	400	700	15.3	2,700	8.5	32.9	....	....
Indianapolis Pr. & Lt. Co., Indianapolis, Ind	Harding St.	1931	8	190	430	725	11.8	838	....	....	5.8	456
Long Island Ltg. Co., Glenwood Landing, L. I	Glenwood No. 2	1928	2	275	450	750	20	1,845	11.7	28	7.5	365
			2	300	....	....	....	....	....	....	....	....
Lynn Gas & Elec. Co., Lynn, Mass	....	1928	2	218	400	700	15.8	746	5.5	51.2	....	....
Jersey Central Pr. & Lt. Co., Sayreville, N. J	Raritan River	1930	4	190	450	675	11.8	518	5.9	38	4.1	300
N. B. Elec. Pr. Comm., Minto, N. B., Can	Grand Lake	1931	2	62	450	650	6.1	1,760	4.3	....	....	....
New York Edison Co., New York, N.Y	East River	1926	6	250	400	725	14.8	4,134	....	....	....	....
			3	1,000	....	....	60.7	7,345	....	....	....	....
N. Y. State El. & Gas Corp. Johnstown City, N. Y	Binghamton	1927	3	150	448	696	10.6	1,250	8.4	25	9.2	389
Northern States Pr. Co., Minneapolis, Minn	Riverside	1931	3	250	450	750	17.7	1,330	10.5	45	12.1	385
Ohio Edison Co., Toronto, O	Toronto	1925	4	250	400	715	20.5	2,100	13.5	25	....	....
			4	300	....	....	21.6	2,576	17	26	....	....
Okla. Gas & Elec. Co., Oklahoma City, Okla	Arthur S. Huey	1930	3	180	400	713	12.7	648	7	33	....	....
Pacific Gas & Elec. Co., Oakland, Calif	Station "C"	1928	2	425	450	735	35.5	....	1.5	37	....	....
Philadelphia Elec. Co., Philadelphia, Pa	Richmond	1925	12	200	400	725	15.7	597	7.8	33	7.5	654
		1935	2	600	425	850	36.2	4,648	26.9	30	....	....
Public Service Co. of N. H., Portsmouth, N. H	[2]Jacona	1930	4	70	430	700	7.8	....	1.1	86	....	....
Puget Sound Pr. & Lt. Co., Renton, Wash	Shuffleton	1929	3	330	450	725	2.5	1,185	59.7	26	....	....
San Antonio Pub. Ser. Co., New Braunfels, Tex	Comal	1926	3	250	450	725	20.5	1,828	16.8	21.5	....	....
Southern Calif. Edison Co., Long Beach, Cal	Long Beach	1928	6	425	455	775	34.2	3,240	19.8	27	....	....
Southern Ind. Gas & El. Co., Evansville, Ind	Ohio River	1929	2	160	475	690	11.5	820	....	....	8.6	322
Southeastern Production Co., Mobile, Ala	Magazine	1929	3	100	475	665	13.1	438	5	23	....	....
Texas Pr. & Lt. Co., Trinidad, Tex	Trinidad	1926	4	185	425	700	18.8	2,520	18	14.6	....	....
			2	325	450	700	31.6	5,360	19.5	23.7	....	....
Twin City Rap. Tran. Co., Minneapolis, Minn	Minneapolis	1932	2	175	425	725	16.4	....	....	....	3.7	450
Municipal Plants												
City of Colorado Springs, Colo	....	1933	1	65	410	582	6.1	....	3.1	31.3	....	....
Water & El. Lt. Comm., Lansing, Mich	Moores Park	1930	2	245	570	708	18.8	846	10.4	31.8	8.4	415
			2	245	....	....	16	812	9	....	7.2	415
Water & Electric Dept., McPherson, Kan	....	1909	2	30	407	700	4	140	2	20	....	....
Pasadena Mun. Lt. & Pr. Dept., Pasadena, Cal	Glenarm	1928	4	150	420	750	15.3	1,000	7.5	35	....	....
City of Piqua, O	....	1933	2	60	400	700	6.8	160	2	47.3	....	....
Water & Lt. Dept., Kansas City, Kan	Quindaro	1932	2	180	450	635	16.3	1,568	10.9	24	1.8	535
Municipal El. Lt. & Pr. Plant, Richmond, Ind	....	....	3	125	450	730	10.4	377	4.7	38	....	....
City of Tacoma, Wash	Plant No. 2	1932	2	184	420	750	16.5	....	14	....	....	....
Dept. of Municipal Ser. Wyandotte, Mich	....	1933	2	54	450	700	6.2	1,648	....	....	....	....

U.S., underfeed stoker; P.C., pulverized coal; O.&G., oil and gas; C.G., chain-grate stoker; G.&S., gas and stoker; S., stoker; P.P., pulverized petroleum coke; P.L., pulverized lignite.

C.C., cross-compound turbine; S.C., single-cylinder turbine; T.C., tandem-compound turbine; V.C., vertical compound turbine; B.P., back-pressure turbine; B.T., bleeder turbine; D.E., double-extraction non-condensing turbine; A., high-pressure plant

Air Preheater Sur., 1,000 Sq. Ft.	Air Temp. Leav. Preh'ter, Deg. F.	F.-D. Fans No. per Boiler	Cap. F.-D. Fans, Ea., 1,000 C.F.M.	I.-D. Fans No. per Boiler	Cap. I-D Fans, Ea., 1,000 C.F.M.	Final Feedwater Temp., Deg. F.	Per Cent Makeup	Type of Firing Equipment	1,000 B.t.u. per Lb. of Fuel	Av. Boiler-Plant Eff., per cent	No. of Turbines	Type of Turbines	Cap. of Turbines Each, 1,000 Kw.	Cap. of H.-P. Unit, Each, 1,000 Kw.	Throttle Ga. Press, Lb. per Sq. In.	Throttle Temp. Deg. F.	No. of Stages, Feed Heating	Condenser-Tube Ar., 1,000 Sq. Ft.	Aux. Pw., Per Cent of Total Gen.	Yearly Load Factor, Per Cent	Yearly Plant-Cap. Factor, Per Cent	Av. St. Water Rate Lb. per Kw.-Hr.
.....	...	1	80	1	150								38	3.4			3	45				
33	410	2	47.5	2	66	308	2.5	U.S.	14.3	84	3	C.C.	38	11.8	1,250	712R	3	45	6.25	50.4	....	9.2
29.7	454	2	47.5	2	70								65	13.8			3	50				
46.6	470	1	75	1	150	415	0.9	P.C.	14	88.9	2	C.C.	53	11	1,240	715R	4	42.5	6.4	73	82	9.8
52.8	...	...	...	...	...	...	...	...	...	...	1	S.C.	...	12.5	1,240	715	Exhaust pressure 400 lb. max.					
31.2	320	2	55	2	105	330	2.5	G.	23.8	78.5	1	A.	...	12	1,282	710R	..	...	6.8	62	60	11.3
32.1	477	2	40	2	62	520	...	P.C.	13.6	84	2	V.C.	25	5.3	1,250	750R	5	20.5	7	70.3	35.2	9.9
39.3	350	1	90	1	153	325	...	P.C.	10.5	85	1	A.	...	10	1,300	725R	..	...	...	70.7	....	....
77.5	635	2	47.5	2	92	300	2.3	P.C.	12.8	86.8	4	A.	...	7.7	1,230	750	..	...	6.5	61.2	61.2	8.4
121	592	2	112.5	2	185	398	1	P.C.	12.8	87.5	1	T.C.	80	...	1,230	825R	5	52.5	...	...	...	....
32.5	405	1	76.5	1	153	303	1	P.C.	13.8	85.8	1	C.C.	55	11.8	1,248	735R	3	31.6	7.5	63	53	7.9
46.9	472	1	135	1	240	425	2	O.&G	18.5	83.6	2	V.C.	50	12.5	1,230	750R	4	34	16.8	17.5	14.4	....
51.6	474	1	165	1	190																	
13.9	342	1	70	1	110	371	7.9	G.	....	75	1	A.	20	8	1,250	810R	3	22.5	17	42.2	26.3	13.1
22.1	340	1	83.5	1	156	300	...	C.G.	10	80	2	B.P.	10	...	600	740	1	...	...	13	...	....
												S.C.	35	...	600	740	2	45	8	55	....	....
42	430	1	96	1	178	300	0.5	P.C.	11.2	85.8	1	S.C.	68	...	675	750	4	50	6.3	43.1	45.8	....
41.8	460	1	168	1	335	340	1.7	O.	18.4	84.4	1	A.	...	18	650	846	..	...	...	60	60	10.5
56.4	400	2	60	2	110	355	1.1	G.&P.C.	...	85	1	C.C	208	76	660	730R	5	176	5.2	60	60	10.9
10	230	2	40	1	115	300	3.5	C.G.	10.2	78.2	1	C.C	51	16	550	750R	4	56				
.....	...	...	...	...	...	...	...	...	...	...	1	C.C.	62	17	550	750R	4	75				
15.9	230	2	45	1	125	300	3.5	C.G.	10.2	78.2	1	C.C.	52	30	550	750R	4	65	4.7	64	45	9.7
.....	...	...	...	...	...	...	...	...	...	...	1	C.C.	77	28	550	750R	4	70.5				
16.0	230	1	90	1	125	300	3.5	C.G.	10.2	78.2	1	C.C.	91	33	550	750R	4	70.5				
17.8	230	1	90	1	125	300	3.5	C.G.	10.2	78.2	1	C.C.	104	45	550	750R	4	90				
9.5	270	1	70.6	1	130	200	2	C.G.	10.4	80	2	S.C.	40	...	600	710R	2	25	5.5	...	...	9.5
18.1	350	1	56	1	80	212	25	G.&S.	11.6	84	2	B.T.	...	6	550	725	3	7.4	11.8	50.5	61.8	12
32.8	439	1	109	2	84	350	80	G.&O.	....	...	3	B.P.	15	...	600	735	Exhaust pressure 140 lb. gage.					
.....	...	1	70.6	1	130	200	1.4	C.G.	11	81	2	S.C.	40	...	580	710R	2	45				
28.1	415	2	50	1	175	290	1.4	C.G.	....	81	1	C.C.	165	53	580	710R	4	110	5.7	60	60	9
43.4	415																					
58.6	460	2	60	1	210	290	1.4	P.C.	.....	81	..	.....	....	...	....	...	...	...	...	...	...	...
47	425	2	50	2	84	364	1	P.C.	14.5	86.4	1	S.C.	35	...	...	...	3	30	4.8	...	...	9.3
90	315	2	32.9	1	112.8	265	3	C.G.	10.5	...	1	S.C.	50	...	625	725	3	57	5.8	62.3	16.8	....
40.1	380	1	76.5	1	145.5	365	2	P.C.	10.5	...	1	T.C.	65	...	625	750R	4	63	5.8	70.6	44.7	....
64.1	490	2	68.6	1	243.3	325	2	P.C.	10.5	...	1	T.C.	115	...	625	750R	4	80	5.8	58.2	48.2	....
40.5	480	2	33	2	56	210	0.9	C.G.	11	78.8	2	S.C	50	...	645	725R	2	33	4.5	88	87	8.8
9.9	278	1	85	1	100	233	3.5	P.C.	13.7	86.5	2	C.C.	63	16	600	720R	3	48	6.5	56	52	9.1
40.7	347	2	43.5	1	150	305	2	P.C.	13.2	86.6	1	S.C.	30	...	650	825	4	24	6.3	35.8	50.3	11.2
90	342	2	95	2	105	356	1	P.C.	13	86.5	2	S.C.	80	...	425	750	4	45	6.7	25.2	27.6	10.2
Diphenyl oxide used in air preheaters						380	2	P.C.	14.4	81	2	T.C.	15	...	450	825	4	13	5	36	28	10.9
30.6	...	1	166	1	358	385	0.5	P.C.	12.5	85	1	S.C.	60	...	425	725	4	70	5	S	S	11.5
43.1	275	2	60	2	90						1	C.C.	80	...	410	690	4	80				
.....	...	1	120	2	105	235	3.5	U.S.	14.1	85.9	2	C.C.	110	...	410	706	2	85	4	49.1	33.5	10.2
.....	...	1	200	2	155						2	T.C.	160	...	410	730	2	101				
.....	...	1.5	65	1	97.5	215	4.6	U.S.	14	....	2	S.C.	15T	...	413	675	3	13	5.8	....	45.4	10.4
.....	...	1	50	1	100	335	2.5	O.	18	80.5	1	T.C.	15	...	375	725	2	16	5.2	63	90	10.5
.....	...	..	.....	1	...	350	1	P.C.	9.8	83.5	2	S.C.	22	...	375	700	2	25	6	55.4	...	12.3
.....	...	..	.....	1	327	330	0.85	P.C.	....	....	3	S.C.	50	...	375	700	2	57	4.3	....	....	....
.....	...	..	.....	1	195	327	1.3	P.C.	.....	...	4	S.C.	35	...	375	700	1	42	4.4	...	...	....
26.8	450	2	75	2	135	365	1.1	P.C.	13.8	84	2	S.C.	36	...	410	725	4	30	5.8	58.4	49.1	11.6
21.6	430	1	55	1	100	300	1.7	P.C.	13.6	82.5	1	S.C.	20	...	375	725	3	25	8.2	24.9	27.4	13.3
29.9	325	2	65	1	223	300	1	U.S.	13.4	84.4	3	S.C.	50	...	375	725	4	60	4.6	48.8	45.8	11.2
.....	...	2	13	1	193	225	1	P.C	13.4	87	6	S.C.	50	...	375	725	3	51.8	4.6	45.4	29.1	10.6
19.5	420	2	75	2	130	280	0.9	G.	....	80	2	S.C.	43T	...	420	740	3	....	4.7	50.1	21.8	11.8
.....	...	2	26	2	67	214	2	O.	18.8	81.6	1	S.C.	15	...	416	698	3	16.5	6.4	36	5.3	13.8
30	435	1	150	1	259	380	...	G.	...	77	1	S.C.	60	...	440	750	4	70	4.8	S	S	10.8
16.9	315	2	30	1	110	325	1	G.	21.5	78	2	S.C.	57T.	...	375	695	4	...	5	60	32.6	12.2
17.8	300	1	66.6	1	110.7	374	3.5	U.S.	10.9	81	2	S.C.	36.7	...	400	700	4	33	5	67	35	10.5
45	255	1	81.5	1	184	344	1.5	P.C.	14.4	86.2	1	S.C.	20	...	415	735	4	24.7	8.1	30.5	53.6	12.4
.....	...	1	125	1	208	...	...	...	...	...	1	S.C.	75	...	...	...	3	65	...	...	...	....
12.1	344	2	31	1	110	275	4	S.	14.3	78.5	1	S.C.	20	...	395	700	3	22	7.6	44.3	21.3	13
3.8	350	1	50	1	80	380	3	U.S.	13.8	77	2	S.C.	30	...	425	650	4	28	5	41	22	11.5
4	325	1	.....	1	.....	320	5	P.C.	12.2	77	2	S.C.	2.5	...	425	625	2	2.5	....	B	B	15
28.9	520	1	60	1	150	300	10	P.C.	14.2	85.9	2	S.C.	60	...	385	735	4	47.5	7.5	46.2	40.6	12.2
82.7	520	2	125	2	260	...	...	...	...	...	1	T.C.	160	...	...	...	4	90	...	...	...	....
12	344	1	28	2	54	214	3.2	P.C.	13.7	77.5	1	S.C.	30	...	385	687	3	22	6.2	65	38.4	11.7
		1	97	2	86	295	0.9	S.	14.2	85.3	1	S.C.	35	...	400	725	3	29	2.1	65	71.4	10.5
11.6	330	1	99	1	129	330	2	P.C.	12.8	84.6	4	S.C.	35	...	356	701	5	50	5.2	53.9	67.3	11.9
32.6	330	1	108	1	161	...	...	...	...	...	..	.....	....	...	...	...	..	...	...	...	...	...
22	421	1	55	1	105	294	0.4	G.	....	83.9	1	S.C.	30	...	395	710	4	33	3.6	33.6	44.5	12.9
51.3	500	1	125	1	209	365	2	O.&G.	.....	83.9	1	S.C.	37.5	...	425	700	4	30	25.5	S.	S.	...
22.1	344	1	60	2	45	290	1.2	U.S.	14.2	86.2	2	T.C.	60	...	375	675	3	70	4.7	61.1	61.1	10.7
48	507	2	102.5	2	190	325	1	P.C.	14.2	86.2	1	T.C.	165	...	375	825	4	113	3	50	50	8.7
7.8	330	0.5	45	0.5	78	225	2	O.	18.3	83	2	S.C.	10	...	410	693	2	13.2	3.5	25.5	28	10.4
55.1	295	2	53	2	105	360	2.5	O.	18.5	81	2	S.C.	40	...	400	725	3	....	2.8	16.4	15.5	11.3
26.6	440	1	73	1	234	370	0.7	G.	....	79.4	2	S.C.	30	...	400	725	4	37.5	5.3	39.5	15.4	12.4
51.2	400	2	53	1	180	387	0.5	O.&G.	18.6	84	2	T.C.	100	...	410	735	4	80	3	54.3	18.9	10.2
		1	55	1	90	216	1.1	U.S.	10.8	84.3	2	S.C.	20T	...	386	690	2	....	5.8	48.6	....	12.7
6.7	325	1	44	1	75	360	25	U.S.	12.5	82	2	D.E.	6	...	425	665	2	Exhaust pressure 5 lb. gage.				
.....	...	1	10	..	.....	330	2	P.L.	7	77	2	S.C.	20	...	375	700	3	20	5.1	61	72	12.1
.....	...	1	50	..	...	...	...	...	...	...	1	S.C.	35	...	...	...	..	35	...	...	...	...
14.1	275	1	55	1	100	350	3	U.S.	14	80	1	S.C.	20	...	400	725	3	33	5	53.8	47.3	11.4
9.9	250	1	26.4	1	49.7	212	1.5	G.	....	81.5	1	S.C.	5	...	400	582	2	6	13	37.5	....	13.9
19.3	268	1	96.5	1	156	260	2.8	U.S.	13.7	84.1	2	S.C.	20	...	425	701	3	21.5	6.1	43.3	10.1	14.2
16.6	268	1	82.5	1	133	...	...	...	....	....	1	S.C.	15	...	...	...	..	...	...	...	...	...
.....	...	..	.....	..	.....	240	3	G.	.....	70	3	S.C.	3.25T	...	400	650	..	....	8.5	50	25	22
.....	450	1	60	1	95	350	1	O.	18.5	85	2	S.C.	40T	...	400	750	..	....	8	42	36	....
1.6	304	1	16	1	47.5	212	3	C.G.	12.5	....	2	S.C.	4	...	380	680	2	6	...	...	...	...
19.6	332	1	194	1	230	225	1.5	P.C.	11.8	78.8	1	S.C.	10	...	400	627	3	15	5.1	81.4	89.6	11.2
7.5	350	1	33	1	180	350	3	U.S.	13.5	65	3	S.C.	30T	...	415	710	..	....	...	....	....	....
34	450	1	65	1	104	350	10	P.C.	10	...	1	S.C.	25	...	375	725	3	18	10	....	....	....
1.6	250	1	22.5	1	44.5	250	2	U.S.	13.7	81	1	S.C.	3	...	400	700	4	3	6	80	80	12.5

superimposed on medium-pressure plant; R., steam reheated before going to low-pressure turbine; T., total capacity of turbines; S., standby service; B., auxiliary to hydro-electric plants.

[1]In addition to units shown there are 12 boilers and three 50,000-kw. turbines operating at 275 lb. and 600 deg. F. steam, making the station capacity 770,000 kw., the largest in the world.

[2]Floating power plant built on the ship "Jacona."

Typical Recent Diesel Installations

Plants Larger Than 100 hp. Installed Since Jan. 1, 1932

Compiled by E. J. Tangerman
Assistant Editor

Owner	Location	Service	Unit Driven	No. of Engines	Hp. per Engine	R.P.M.	No. Cyl.	Cyl. Bore, In.	Cyl. Stroke, In.	Cycle	Acting	Fuel Injection	Fuel Consumption lb. per b. hp. hr.	Kw.-hr. p.r Gal. Full Load
City of Vernon	California	Mun. C.S.	Gen.	5	7,000	167	8	24	36	2	D	S	0.385	13.5
Tucson Gas, E.L. & P. Co.	Tucson, Ariz	Supp. C.S.	F. Gen.	1	4,100	124	6	30	42	2	S	S	0.416	14.5
Pau Corp (Stock Yd.)	Chicago, Ill.	Supp. C.S.	F. Gen.	1	3,000	240	10	19½	27	2	S	S	0.41	.....
Village of Freeport	Long Island, N.Y.	Mun. C.S. Supp.	F. Gen.	1	3,000	240	10	19½	27	2	S	S	0.41	11.75
Rockville Center	Long Island, N.Y.	Mun. C.S.	Altr.	1	2,865	120	8	29	48	4	S	A	....	.....
Public Serv. of Colo.	Sterling Colo.	Supp. C.S.	F. Gen.	1	2,750	240	10	19½	27	2	S	S	0.41	13.3
West. Pub. Serv. Co.	Chadrón, Neb.	C.S.	Gen.	1	1,500	240	5	19½	27	2	S	S	....	11.73
City of Bryan	Ohio	Mun. C.S.	Gen.	1	1,500	257	6	17	25	2	S	A	....	.....
City of Greenville	Texas	Mun. C.S.	Gen.	1	1,450	257	6	17	25	2	S	S	0.38	13.5
				1	1,000	257	4	17	25	2	S	S		
City of Rensselaer	Indiana	Mun. C.S.	Gen.	1	1,450	257	6	17	25	2	S	S	....	.....
City ofLubbock	Texas	Mun. C.S.	Gen.	1	1,450	257	6	17	25	2	S	S	....	.....
Union Const. Co.	Des Moines, Ia.	Dredge	Pump	1	1,225	300	7	16	20	2	S	S	0.39	.....
West. Pub. Serv. Co.	Sidney, Neb.	C.S.	Gen.	1	1,200	257	8	16	20	2	S	S	0.41	11.5
City of Hudson	Mass.	Supp. Mun. C.S.	Gen.	1	1,200	277	6	20	24	4	S	S	0.39	12.5
Sioux Falls	S. Dakota	Mun. Lt.	Gen.	1	1,250	257	5	17	25	2	S	S	....	.....
City of Grand Haven	Mich.	Mun. C.S. Add.	Gen.	1	1,140	200	6	22	30	4	S	S	0.42	.....
Inland Util. Co	Scott City, Kan.	C.S.	Gen.	1	1,120	277	7	16	20	2	S	S	0.41	13
				1	600	257	4	16	20	2	S	S		
Northwestern Pub. Serv. Co.	Webster, S. D	Emergency	Gen.	1	1,120	277	7	16	20	2	S	S	0.41	11.8
Missouri Serv. Co.	Tarkio, Mo.	C.S.	Gen.	1	1,050	257	7	16	20	2	S	S	0.41	11.5
				2	360									
West. Pub. Serv. Co.	Ogallala, Neb.	C.S.	Gen.	1	1,050	257	7	16	20	2	S	S	0.41	11.5
West. Pub. Serv. Co.	Orleans, Neb.	C.S.	Gen.	1	1,050	257	7	16	20	2	S	S	0.41	11.5
City of Denton	Texas	Mun. C.S.	Gen.	1	1,000	225	8	17½	25	4	S	A	0.42	.....
Town of Greenport	N.Y.	Mun. C.S.	Altr.	1	1,000	225	8	17½	25	4	S	S	0.39	.....
City of Russell	Kans.	Mun. C.S. Add.	Gen.	1	1,000	240	8	17½	24	4	S	S	0.42	.....
Atlantic Gulf & Pacific	Florida	Dredge	Gen.	2	1,000	275	8	16	24	4	S	S	0.40	.....
Imperial Irrigation District	El Centro, Cal.	Lt. & Pumps	Gen.	3	1,000	...	3	21½	27½	2	S	S	0.39	.....
McWilliams Dredge Co.	Jacksonville, Fla.	Dredges	Pump & Gen.	1	1,000	...	8	17	25	..	..	..	....	.....
				3	100	514	4	8	10½	4	S	S	0.41	.....
250-1,000 Horsepower Per Engine														
Wm. E. Hooper Co.	Baltimore, Md.	Mill	Gen.	2	950	214	8	17½	25	4	S	S	0.39	13.8
Ellicott Machine Corp.	Baltimore, Md.	Dredge	Pump & Gen.	1	940	300	6	14¾	21	2	S	S	0.42	.....
				1	450	360	6	13	17	4	S	S	0.41	.....
Jewell Cotton Mills	Thomasville, N. C.	Pwr.	Gen.	1	940	200	5	22	30	4	S	S	0.42	.....
McIntosh & Seymour Corp.	Auburn, N. Y.	Mill Add.	Gen.	1	950	235	6	20	24	4	S	A	0.40	.....
				1	625	235	5	17½	25	4	S	S	0.39	.....
City of Marshall	Minn.	Mun. C.S. Supp.	Altr.	1	875	300	5	16	20	2	S	S	0.41	11.7
Village of Oberlin	Ohio	Mun. C.S.	Gen.	2	875	300	5	16	20	..	..	..	....	12.96
				1	600	400	6	12	15	2	S	S	....	12.02
Columbia University	New York City	Priv. C.S. Supp.	Gen.	1	850	360	8	14	20	4	S	S	0.375	.....
				1	635	360	6							
Commander Mllg. Co.	Minneapolis, Minn.	Flour Mill	Gen.	3	800	277	5	16	20	2	S	S	0.41	11.7
Greenville Mfg. Co.	Greenville, Ohio	Dredge	Gen.	2	800	360	8	14½	17	4	S	S	0.40	.....
Grant Dredging Co.	Madison, Ind.	Dredge	Altr.	1	800	360	8	14½	18	4	S	S	....	.....
Grant Dredging Co.	Rising Sun, Ind.	Dredge	Altr.	1	800	360	8	14½	18	4	S	S	....	.....
City of Slater	Mo.	Mun. C.S.	Gen.	1	800	277	5	16	20	2	S	S	....	12.87
Stanolind Pipe Line Co.	Hufsmith, Tex.	Pipe Line	Pump	1	750	257	3	17	25	2	S	S	....	.....
New Era Milling Co.	Arkansas City, Kan.	Plt. Pr.	Gen. & Shaft	1	750	275	6	16	24	4	S	S	0.40	.....
City of Newcastle	Indiana	Mun. Water	Altr.	1	750	240	6	17½	24	4	S	S	....	11.32
			Altr.	1	500	240	4	17½	24	4	S	S		
City of Bloomington	Illinois	Mun. C.S.	Altr.	3	750	257	5	16	20	2	S	S	0.414	11.75
Price Dredging Co.	Miami, Fla.	Dredge	Pump	1	700	327	8	14½	18	4	S	S	....	.....
Progress Brewing Co.	Okla. City, Okla.	Plt. Pr.	Gen.	1	700	...	..	16	20	..	..	..	....	12.87
				1	280	300	4	14	17	2	S	S	....	12.13
Hudson River Stone Corp.	Cold Spring, N. Y.	C.S. and Comp. Air	Gen. Comp.	3	660	300	6	16	20	4	S	S	0.39	.....
				2	160	327	4	10¾	13¾	4	S	S		
City of Grafton	N. D.	Mun. C.S.	Gen.	1	630	300	6	14	17	2	S	S	....	11.92
City of Morgan City	La.	Mun. C.S.	Gen.	2	630	300	6	14	17	2	S	S	....	11.92
City of Tahlequah	Okla.	Mun. Lt.	Gen.	1	625	225	5	17½	25	4	S	A	0.40	.....
Balatoc Mining Co.	Manilla, P. I.	Mining	Gen.	5	625	225	5	17	25	4	S	S	0.40	.....
Ferguson Bros.	Hoboken, N. J.	Plt. Pr.	Gen.	1	625	225	5	17	25	4	S	S	0.40	.....
				1	400	225	4	17	25	4	S	S	0.40	.....
Ipo Mining Co.	Philippine Is.	Plt. Pr.	Gen.	1	625	225	5	17	25	4	S	S	0.40	.....
Town of Osawatomie	Kansas	Mun. Lt.	Gen.	1	615	300	8	12½	22	4	S	S	0.39	.....
So. Ice & Storage Co.	San Antonio, Tex.	Ice Plt.	Gen.	1	600	257	6	16½	23	4	S	A	.....	.....
				1	480	257	4	16½	23	4	S	A		
Kansas Milling Co.	Wichita, Kans.	Mill	Gen.	1	600	225	6	16	24	4	S	A	0.40	.....
City of Lamar	Missouri	Mun. Lt. Supp.	Gen.	1	600	400	6	12	15	2	S	S	0.42	11.87
Hilo Elec. Lt. Co.	Hilo, T.H.	Indus.	Gen.	1	600	225	6	16½	23	4	S	A	....	.....
General Motors Bldg.	Chi. World's Fair	Priv. C.S.	Gen.	2	600	720	8	8	10	2	S	S	....	.....
Provincetown Lt. & Pr. Co.	Provincetown, Mass.	Priv. C.S.	Gen.	1	600	400	6	12	15	2	S	S	....	12.02
Thomaston Mfg. Co.	Thomaston, Conn.	Plt.Pr.	Shaft	1	50	550	3	6¾	8¾	2	S	S	0.51	.....
C. C. Beaun Inc.	Melvin, O.	Quarry	Gen.	1	525	300	5	14	17	2	S	S	....	11.82
City of Paris	Ky.	Mun.C.S.	Gen.	2	525	300	5	14	17	2	S	S	....	11.82
Village of Sebewaing	Mich.	Mun. C.S.	Gen.	1	525	300	5	14	17	2	S	S	....	11.82
City of Vermilion	So. Dakota	Mun. Lt.	Gen.	2	525	300	7	14	17	2	S	S	0.42	.....
Iowa Elec. Co.	Anamosa, Ia.	C.S.	Altr.	1	510	277	6	14	21	4	S	S	....	.....
Haytian-Amer. Development Corp.	Cape Haitian, Haiti	Priv. C.S. Supp.	Gen.	1	500	225	4	17½	25	4	S	A	....	.....
City of Carmi	Illinois	Mun. C.S.	Gen.	1	500	400	5	12	15	2	S	S	....	11.95
Standish Oil Co.	Kansas City, Kan.	Pumping	Pumps	1	450	327	6	13½	17½	4	S	S	0.39	.....
Elko Lamoille Power Co.	Elko, Nev.	Priv. C.S.	Gen.	1	450	360	6	13	17	4	S	A	0.465	.....
New Ulm Roller Mills	New Ulm, Minn.	Plt. Pwr.	Gen.	1	450	327	6	13½	17½	4	S	S	0.39	.....
Village of Bath	N.Y.	Mun. C.S.	Gen.	2	450	327	6	13½	17½	4	S	S	0.39	12.26
				1	300	400	6	10¾	14½	4	S	S	0.40	12.26
Railway Steel Sprg. Co.	Chicago Hts., Ill.	Mill	Gen.	1	450	360	6	12½	18	4	S	S	0.39	.....
				1	225	360	3	12½	18	4	S	S	0.39	
New Mexico Const. Co.	Santa Rosa, N. M.	Quarry	Gen.	1	450	257	6	14	21	4	S	S	....	.....
Independent Oil & Gas Co.	Kansas City, Kan.	Pumping	Pumps	1	450	327	6	13½	17½	4	S	S	0.39	.....
Manor Road Brewery	Staten Island, N. Y.	Pwr. & Refrig.	Gen.	2	440	420	..	11	14	4	S	S	0.39	.....
Wolf Milling Co.	Ellinwood, Kan.	Plt. Pr.	.....	1	420	300	6	14	17	2	S	S	0.40	.....
Caroill Grain Co.	Minneapolis, Minn.	Floor Mill	Gen.	1	420	300	6	14	17	2	S	S	....	12
				1	210	300	3	14	17	2	S	S	....	12
City of Geneseo	Ill.	Mun. C.S.	Gen.	2	420	300	6	14	17	2	S	S	....	.....
				1	280	300	4	14	17	2	S	S	....	12.13
Texas Corp.	Henderson, Tex.	Pipe Line	Pump	2	420	600	6	8¼	11	4	S	S	.....	.....
Consumers Ice Co.	Trenton, N. J.	Ice Plt.	Comp. & Gen.	1	400	300	5	15	18¼	4	S	S	0.44	.....
City of Ashland	Kan.	Mun. C.S.	Gen.	1	400	225	4	16½	23	4	S	A	0.43	.....
Town of Culpeper	Va.	Mun. C.S.	Gen.	2	400	300	5	15	18¼	4	S	S	....	.....
				1	240	300	3	15	18¼	4	S	S	....	.....
City of Siloam Springs	Arkansas	Mun. C.S.	Altr.	2	375	360	3	16	20	4	S	S	0.41	.....
Brown Linseed Co.	Elm Park, L. I.	Priv. C.S.	Gen.	1	375	327	5	13¼	17½	4	S	S	....	.....
				1	300	327	4	13¼	17½	4	S	S		

Typical Recent Diesel Installations—(Continued)

Owner	Location	Service	Unit Driven	No. of Engines	Hp. per Engine	R.P.M.	No. Cyl.	Cyl. Bore, In.	Cyl. Stroke, In.	Cycle	Acting	Fuel Injection	Fuel Consumption lb. per b. hp. hr.	Kw.-hr. per Gal. Full Load
F. E. Schumacker	Hartville, Ohio	Plt. Pr.	Gen.	1	375	327	5	13½	17½	4	S	S	0.39	.....
				1	50	514	2	8	10½	4	S	S	0.41	.....
Lindo Bros.	Kingston, Jamaica	Plt. Pr.	Gen.	1	375	327	5	13½	17½	4	S	S	0.39	.....
Gold River Mining Co.	Philippine Is.	Mining	Gen.	1	375	225	3	17	25	4	S	S	.....	.....
Public Utilities of Calif.	Crescent City, Calif.	C.S.	Gen.	1	375	327	5	13½	17½	4	S	S	0.39	.....
City of Plainview	Nebraska	Mun. C.S.	Altr.	1	375	360	6	12½	15	4	S	S	.....	.....
National Pk. Service	Mt. Rainier, Wash.	C.S.	Altr.	1	360	360	6	13	16	4	S	S	0.43	11.1
				1	265	277	6	12½	16	4	S	S	0.43	11.1
City of Wauchula	Fla.	Mun. C.S.	Gen.	1	360	257	6	14	17	2	S	S	.....	12.23
Freeport Sulphur Co.	Freeport, Tex.	Dredge	Pump & Gen.	1	300	360	5	11	18	4	S	S	0.42	.....
				1	350	360	6	11	18	4	S	S	0.32	.....
City of Memphis	Mo.	Mun. C.S.	Gen.	1	350	300	5	14	17	2	S	S	.....	12.23
Village of Bethel	Ohio	Mun. C.S.	Gen.	1	350	300	5	14	17	2	S	S	.....	12.23
Pure Oil Co.	Muskogee, Okla.	Refinery	Gen.	3	350	300	5	14	17	2	S	S	.....	12.23
Village of Woodsfield	Ohio	Mun. C.S.	Gen.	1	350	300	5	14	17	2	S	S	.....	12.23
Tennant & Hoyt Co.	Lake City, Minn.	Flour Mill	Altr.	2	350	300	5	14	17	2	S	S	0.41	11.2
Atlantic Pipe Line Co.	3 Stations	Pumping	F. Gen.	7	340	400	6	11½	15	4	S	S	0.41	.....
Great Lakes Pipe Line Co.	Osceola, Ia.	Pumping	Pumps	2	330	270	6	14	16	4	S	S	0.39	.....
				1	120	250	3	12½	16					
Great Lakes Pipe Line Co.	Barnsdall, Okla.	Pumping	Pumps	2	330	270	6	14	16	4	S	S	0.39	.....
Great Lakes Pipe Line	Independence, Kans.	Pumping	Pumps	2	330	270	6	14	16	4	S	S	0.39	.....
Great Lakes Pipe Line Co.	Humboldt, Kans.	Pumping	Pumps	2	330	270	6	14	16	4	S	S	0.39	.....
Great Lakes Pipe Line Co.	Kansas City, Kans.	Pumping	Pumps	2	330	270	6	14	16	4	S	S	0.39	.....
Atlantic Refining Co.	.....	Plt. Pr.	Gen.	2	330	360	6	11½	15	4	S	S	0.40	.....
City of Arcanum	Ohio	Mun. C.S.	Gen.	1	320	300	4	15	18½	4	S	S	0.44	10
Geyser Ice Co.	Waco, Tex.	Ice. Plt.	Comp.	1	312	300	5	13	17	4	S	S	.....	.....
			Gen.	1	188	300	3	13	17	4	S	S	.....	.....
City of Bellevue	Iowa	C.S. Mun.	Altr.	2	300	257	4	14	21	4	S	S	0.40	.....
Village of Kenyon	Minn.	Mun. C.S.	Gen.	2	300	327	4	13½	17½	4	S	S	.....	10.6
				1	150	514	6	8	10½	4	S	S		
Sanmahana Magsasaka Power Plant	Manila, P. I.	Mun. C.S.	Gen.	1	300	327	4	15	18½	2	S	S	.....	.....
				1	150	327	2	15	18½	2	S	S		
India Wharf Brewing Co.	Brooklyn, N. Y.	Plt. Pr.	Altr.	2	300	400	6	10½	15½	4	S	S	.....	.....
Town of Canton	Mo.	Mun. C.S.	Gen.	1	300	257	5	14	17	2	S	S	.....	12.02
Wilbanks & Pierce, Inc.	New Orleans, La.	Dredge	Gen.	1	300	360	4	13	17	4	S	S	0.41	.....
Village of Greene	N. Y.	Mun. C.S.	Gen.	1	300	360	5	10½	12½	2	S	S	.....	11.11
Burdett Oxygen Co.	Cleveland, Ohio	Plt. Pr.	Gen.	1	300	257	5	14	17	2	S	S	.....	11.11
Illinois Powder Mfg. Co.	Grafton, Ill.	Plt. Pr.	Gen.	1	300	360	5	11	18	4	S	S	0.42	.....
Home Ice Co.	Paducah, Ky.	Plt. Pr.	Gen.	1	300	400	8	9½	14	4	S	S	.....	.....
Frank Tea & Spice Co.	Cincinnati, Ohio	Plt. Pr.	Gen.	1	300	327	4	13½	17½	4	S	S	0.39	.....
Ozora Marble Quarries Co.	St. Louis, Mo.	Quarry	Gen.	1	280	300	4	14	17	2	S	S	.....	12.13
				1	240	257	4	14	17	2	S	S	.....	12.06
Wisconsin Oxygen Co.	Kenosha, Wis	Plt. Pr.	Gen.	1	280	300	4	14	17	2	S	S	.....	12
				1	210	300	3	14	17	2	S	S	.....	12
City of Burlington	Colo.	Mun. C.S.	Gen.	1	280	300	4	14	17	2	S	S	.....	11.71
				1	140	300	2	14	17	2	S	S	.....	11.71
Sunbury Milk Products Co.	Sunbury, Pa.	Plt. Pwr.	Gen.	1	280	400	4	12½	15	4	S	S	0.40	.....
				1	210	400	3							
Town of Wray	Colo.	Mun. C.S.	Gen.	1	280	300	4	14	17	2	S	S	.....	11.71
				1	140	300	2	14	17	2	S	S	.....	11.71
Quincy Stove Mfg. Co.	Quincy, Ill.	Plt. Pr.	Gen.	1	280	375	6	10½	15	4	S	S	.....	.....
Town of Covington	Tenn.	Mun. C.S.	Gen.	1	280	300	4	14	17	2	S	S	.....	12.13
Trinity Farm Const. Co.	Dallas, Tex.	Dredge	Shaft	1	280	300	4	14	17	2	S	S	0.40	.....
Timms Gold Dredging Co.	Portland, Ore.	.....	Gen.	1	280	300	4	14	17	2	S	S	.....	12.13
C. I. Jones Const. Co.	Baton Rouge, La.	Dredge	Shaft	1	280	300	4	14	17	2	S	S	0.40	.....
Delaware Dredging Co.	Philadelphia, Pa.	Dredge	Gen.	1	280	400	4	12½	15	4	S	S	.....	.....
No. 1 Pk. Ave. Corp.	New York City	Priv. C.S.	Gen.	4	270	360	6	10½	13½	4	S	S	0.42	.....
Kapaa Elec. Co.	Hawaii	Indus.	Gen.	1	270	360	4	12½	16	4	S	S	0.45	.....
Laurinburg Milling Co.	Laurinburg, N. C.	Plt. Pr.	Shaft & Gen.	1	262½	400	7	9½	14	4	S	S	.....	.....
Ralston Purina Co.	St. Louis, Mo.	Plt. Pr.	Gen.	1	262½	400	7	9½	14	4	S	S	.....	.....
Wissota Sand & Gravel Co.	Eau Claire, Wis.	Priv. C.S.	Gravel Plant	1	260	200	2	19	23	2	S	S	0.50	.....
Nutwood Drainage & Levee Dist.	Jerseyville, Ill.	Pumping	Pumps	1	250	400	5	10½	14½	4	S	S	0.40	.....
Tidewater Pipeline Co.	Conroe, Tex.	Pipe Line	Pumps	1	250	400	5	10½	14½	4	S	S	0.40	.....
				1	200	400	4	10½	14½	4	S	S	0.40	.....
100-250 Horsepower Per Engine														
City of Remsen	Iowa	Mun. C.S.	Gen.	2	240	300	3	15	18½	4	S	S	0.42	.....
Meckley Ice Co.	Steelton, Pa.	Plt. Pr.	Gen. & Shaft	1	240	300	3	13	18	4	S	S	.....	.....
Superior Metal Co.	Bethlehem, Pa.	Plt. Pr. Add.	Gen.	1	240	277	4	13½	17	4	S	S	.....	.....
City of Unionville	Mo.	Mun. C.S.	Gen.	2	240	257	4	14	17	2	S	S	.....	12
American Caramel Co.	Lancaster, Pa.	Plt. Pr.	Gen.	1	240	257	4	14	17	2	S	S	.....	11.13
				1	110	360	2	12	15	2	S	S	.....	11.13
Town of Grand Junction	Ia.	Mun. C.S.	Gen.	2	240	257	2	14	17	2	S	S	.....	12
Richards Milling Co.	Cortland, Ohio	Mill	Mill & Alt.	1	240	300	3	13½	18	4	S	S	0.40	.....
Borough of Emaus	Penna.	Mun. Water	Altr.	1	240	300	4	13½	17	4	S	S	.....	.....
Edw. J. Nell Co.	Manilla, P. I.	Plt. Pr.	Gen.	5	225	327	3	13½	17½	4	S	S	0.39	.....
National Park Service	Carlsbad Caverns, N. M.	.....	Gen.	1	225	327	3	13½	17½	4	S	S	0.39	.....
General Mills Corp.	El Reno, Okla.	Flour Mi'	Gen.	1	225	360	3	12½	18	4	S	S	0.39	.....
Minneapolis Dredging Co.	Minneapolis, Minn.	Dredge	Gen.	1	225	360	3	13	17	4	S	S	0.41	.....
J. B. Williams Co.	Glastenbury, Conn.	Plt. Pr.	Gen.	1	215	360	4	11	18	4	S	S	0.42	.....
Ideal Coal & Ice Co.	Bridgeport, Conn.	Plt. Pr.	Gen.	3	210	300	3	14	17	2	S	S	.....	12
Rockford Screw Products Co.	Rockford, Ill.	Plt. Pr.	Gen.	2	210	300	3	14	17	2	S	S	.....	12
Boro of Coraopolis	Pa.	Mun. Water	Gen.	1	210	300	3	14	17	2	S	S	.....	11.71
				1	140	300	2	14	17	2	S	S	.....	11.71
Village of Moose Lake	Minn.	Mun. C.S.	Gen.	1	210	300	4	14	17	2	S	S	.....	11.71
				1	140	300	3	14	17	2	S	S	.....	11.71
Tweedie Footwear Corp.	Jefferson City, Mo.	Plt. Pr.	Gen.	1	210	300	3	14	17	2	S	S	.....	12
Boro of Pemberton	N. J.	Mun. C.S.	Gen.	1	210	300	3	14	17	2	S	S	.....	12
Connecticut Valley Brewing Co.	Meriden, Conn.	Plt. Pr.	Gen.	1	210	300	3	14	17	2	S	S	.....	12
Carolina's Ice Co.	Charlotte, N. C.	Plt. Pr.	Am. Comp.	1	210	300	3	14	17	2	S	S	0.40	.....
Town of Lenoir City	Tenn.	Mun. Water	Gen.	1	210	300	3	14	17	2	S	S	.....	12
Randolph Milling Co.	Ava, Ill.	Flour Mill	.....	1	210	300	3	14	17	2	S	S	0.40	.....
City Center Market	Newark, N. J.	Priv. C.S.	Gen.	2	200	500	6	9	10½	4	S	S	0.45	11
San Luis Mining Co.	Tepehuanes, DGO, Mex.	Mining	Gen.	2	200	400	4	10½	14½	4	S	S	0.40	.....
Bell Oil & Gas Co.	Grandfield, Okla.	Pumping	Pumps	1	200	400	4	10½	14½	4	S	S	0.40	.....
City of Midland	Mich.	Mun. C.S.	Gen.	1	200	400	4	10½	14½	4	S	S	0.40	.....
Taylor Refining Co.	Tyler, Tex.	Pumping	Pumps	1	200	400	4	10½	14½	4	S	S	0.40	.....
Home Ice Co.	Paducah, Ky.	Priv. C.S.	Gen.	1	200	500	6	9	10½	4	S	S	0.45	11
Greens Mill	Whitehouse, N. J.	Gravel Plt.	Gen.	1	200	500	6	9	10½	4	S	S	0.45	11
Somerset Crushing Co.	Bernardsville, N. J.	Priv. C.S.	Gen.	1	200	500	6	9	10½	4	S	S	0.45	11
Mullens Gin	Lyon, Miss.	Priv. C.S.	Gen.	1	200	300	2	16½	18½	2	S	S	.....	.....
Thornton Bros.	Kinross, Mich.	Gravel	Gen.	1	200	327	3	13	16½	4	S	S	0.41	.....
Adams Stone Co.	Hanover, Pa.	Plt. Pr.	Shaft & Gen.	1	90	240	1	16	20	2	S	S	.....	.....
				1	190	240	2	16	20	2	S	S		
Penn. Brewery	Steelton, Pa.	Plt. Pr.	Gen. & Shaft	1	187½	400	5	9½	14	4	S	S	.....	.....
Ind. Life Ins. Bldg.	Nashville, Tenn.	Plt. Pr.	Gen.	1	187½	400	5	9½	14	4	S	S	.....	.....
H. M. Noack & Son	Arlington, Minn.	Plt.Pr.	Gen.	1	187½	400	5	9½	14	4	S	S	.....	.....
Tale Mining & Milling Corp.	Glendon, N. C.	Priv. C.S.	Gen.	1	180	327	6	8½	12	4	S	S	.....	.....
Great Lakes Pipe Line Co.	Grinnell, Ia.	Pumping	Pump	2	170	270	3	14	16	4	S	S	0.39	.....

Typical Recent Diesel Installations—(Continued)

Owner	Location	Service	Unit Driven	No. of Engines	Hp. per Engine	R.P.M.	No. Cyl.	Cyl. Bore, In.	Cyl. Stroke, In.	Cycle	Acting	Fuel Injection	Fuel Consumption lb. per b. hp. hr.	Kw.-hr. per Gal. Full Load
Bevin Bros.	East Hampton, Conn.	Plt. Pr. Add.	Gen.	1	170	164	1	21	34½	4	S	S	0.41	.....
Vinalhaven Lt. & Pr. Co.	Vinalhaven, Me.	C.S.	Gen.	1	165	360	3	12	15	2	S	S	....	11.13
				1	110	360	2	12	15	2	S	S	....	11.13
Lowrimore & Irwin	Littlefield, Tex.	Cotton Gin	Shaft	1	165	360	3	12	15	2	S	S	0.42	.....
City of Crown Point	Ind.	Mun. C.S.	Gen.	2	165	360	3	12	15	2	S	S	....	11.38
Manatee County Growers	Bradentown, Fla.	Refrig.	Comp.	1	165	360	3	12	15	2	S	S	0.42	.....
Sheppard & Perkins	Blair, Okla.	Plt. Pr.	Gins & Clnrs.	1	165	230	1	22	24	2	S	S	....	.....
Chas. Brunk	Frederick, Okla.	Cotton Gin	Gin Stands.	1	165	230	1	22	24	2	S	S	0.48	.....
Rockingham Mllg. Co.	Harrisonburg, Va.	Mill	Gen.	1	162	360	3	12	15	2	S	S	0.42	10
Roslyn Water Works	Long Island, N. Y.	Mun. Water	Pump	1	160	600	4	9	11	4	S	S	0.45	.....
John Royle & Sons	Paterson, N. J.	Plt. Pwr.	Gen.	1	150	514	5	9½	10½	4	S	S	0.42	.....
Blytheville Cotton Oil Co.	Blytheville, Ark.	Priv. C.S.	Gin	1	150	327	2	15	16½	2	S	S	....	.....
Mason City	Neb.	Mun. C.S.	Gen.	1	150	514	6	8	10½	4	S	S	0.41	.....
Sayre Water Co.	Sayre, Pa.	Water Plt.	Pumps	1	150	400	3	10½	16	4	S	S	0.39	.....
Mt. Vernon Furnace & Mfg. Co.	Mt. Vernon, Ill.	Plt. Pr.	Gen.	1	150	400	3	10½	14½	4	S	S	0.41	.....
Ball Milling Co.	Lanesville, Ohio	Plt. Pr.	Gen.	1	150	400	4	9½	14	4	S	S	....	.....
Pocatello Cold Strge. Co.	Pocatello, Ida.	Plt. Pr.	Gen.	1	150	400	4	9½	14	4	S	S	....	.....
Colonial Furniture Co.	Grand Rapids, Mich.	Plt. Pr.	Gen.	1	150	400	4	9½	14	4	S	S	....	.....
Siler City Mills	Siler City, N. C.	Plt. Pr.	Shaft	1	150	400	4	9½	14	4	S	S	....	.....
Sanford Mllg. Co.	Sanford, N. C.	Plt. Pr.	Shaft	1	150	400	4	9½	14	4	S	S	....	.....
City of Auburn	Nebr.	Mun. C.S.	Gen.	1	150	514	6	8	10½	4	S	S	0.41	.....
Farmers Gin Co.	Big Springs, Tex.	Cotton Gin	Shaft	1	150	514	6	8	10½	4	S	S	0.41	.....
J. J. Hemphill Farms Corp.	Kennett, Mo.	Plt. Pr.	Shaft	1	150	400	4	9½	14	4	S	S	....	.....
Village of Stryker	Ohio	Mun. C.S.	Gen.	2	140	300	2	14	17	2	S	S	....	11.71
				1	55	360	1	12	15	2	S	S	....	11.71
Euclid Water Co.	Upland, Calif.	Irrigation	Pumps	2	140	300	2	14	17	2	S	S	0.40	.....
Lufkin Ice Co.	Lufkin, Tex.	Plt. Pr.	.....	2	140	300	2	14	17	2	S	S	0.40	.....
Sears, Roebuck & Co.	Camden, N. J.	Priv. C.S.	Gen.	2	140	300	2	14	17	2	S	S	....	11.71
Lakewood Water Co.	Madison, Tenn.	Water Wks.	.....	1	140	300	2	14	17	2	S	S	0.40	.....
Esse Brothers	Fashing, Tex.	Cotton Gin	Shaft	1	140	300	2	14	17	2	S	S	0.40	.....
White River Materials Co.	Hazleton, Ind.	Dredge	Shaft	1	140	600	4	8½	11	4	S	S	....	.....
Village of Hawley	Minn.	Mun. C.S.	Gen.	1	140	300	2	14	17	2	S	S	0.41	10.6
				1	110	360	2	12	15	2	S	S	0.42	10.3
Travers City Milling Co.	Travers City, Mich.	Plt. Pr.	Shaft	1	140	300	2	14	17	2	S	S	0.40	.....
Lyndonville Ice & Cold Stor. Co.	Lyndonville, N. Y.	Plt. Pr.	Shaft	1	140	300	2	14	17	2	S	S	0.40	.....
Ventura Farms, Inc.	Oxnard, Calif.	Irrigation	Pumps	1	140	300	2	14	17	2	S	S	0.40	.....
M. C. & G. W. Clayton	Bailey, Tex.	Cotton Gin	Shaft	1	140	300	2	14	17	2	S	S	0.40	.....
Village of Bainbridge	Ohio	Mun. C.S.	Gen.	1	140	300	2	14	17	2	S	S	....	11.71
Plainville Electro Plating Co.	Plainville, Conn.	Plt. Pr.	Gen.	1	135	360	4	9	14	4	S	S	....	11
Dewey Bros.	Leesburg, Ohio	Flour Mill	Shaft	1	135	300	2	13½	17	4	S	S	0.40	.....
Harp Bros. Inc., & A. R. McGuire	Lynx Creek, Ariz.	Gold Dredge	Line Shaft	1	135	700	6	7	9	4	S	S	....	.....
Clay County Ice Co.	Corning, Ark.	Priv. C.S.	Gen.	1	130	450	2	..	..	4	S	S	0.42	.....
Braintree-Weymouth	Mass.	Sewage	Pump	2	125	200	3	10	14	4	S	S	....	10.44
				1	8	1,000	1	4½	5½	4	S	S	0.48	.....
Lorenz Freimann	Sandusky, Ohio	Brewery	Comp. & Gen.	1	125	260	2	14½	17	2	S	S	....	.....
Hancock Brick Co.	Saginaw, Mich.	Plt. Pr.	Shaft	1	125	200	1	19	23	2	S	S	....	.....
Jamaica Water Supply Co.	Jamaica, N. Y.	Mun. Water	Pumps	2	125	400	5	8¾	10½	2	S	S	0.43	.....
Reamer Ice & Fuel Co.	Columbia, S. C.	Ice Plt.	Gen.	2	125	514	5	8	10½	4	S	S	0.41	.....
Columbia Ice Co.	Lake City, Fla.	Ice Plt.	Comp.	1	125	514	5	8	10½	4	S	S	0.41	.....
Houston Hotel	Dothan, Ala.	Priv. Pr.	Gen.	1	125	514	5	8	10½	4	S	S	0.41	.....
Kansas City & Memphis Farms Co.	W. Ridge, Ark.	Plt. Pr.	Gins & Clnrs.	1	125	260	2	14½	17	2	S	S	....	.....
McDonald Ice Co.	McDonald, Pa.	Plt. Pr.	Comp. & Gen.	1	125	260	2	14½	17	2	S	S	....	.....
Kuenzli Quarries Co.	Upper Sandusky, Ohio	Quarry	Crush. & Gen.	1	125	260	2	14½	17	2	S	S	0.45	.....
Hat Island Sand & Gravel Co.	Hat Island, Wash.	Gravel Sluicing	Pump	1	120	450	4	8¾	10½	2	S	S	0.42	.....
Great Lakes Pipe Line Co.	Corning, Ia.	Pumping	Pump	1	120	250	3	12½	16	4	S	S	0.39	.....
Great Lakes Pipe Line Co.	Muskogee, Okla.	Pumping	Pump	1	120	250	3	12½	16	4	S	S	0.39	.....
City of Waycross	Georgia	Mun. Lt.	Gen.	1	120	600	3	9	11	4	S	S	0.41	12.5
Nabesna Mining Corp.	Chitina, Alaska	Gold Mine	Altr.	1	120	360	4	10	12½	4	S	S	0.44	10.9
City of Burlington	No. Carolina	Mun. Water	Pump	1	120	600	3	9	11	4	S	S	....	12.5
Saucon Brick Co.	Bethlehem, Pa.	Brick Plt.	Line Shaft	1	120	300	2	12	16	2	S	S	....	.....
				1	60	300	1	12	16	2	S	S		
Morgan City	Utah	Mun. C.S.	Altr.	1	115	720	5	7	9	4	S	S	....	.....
Sierra Pacific Power Co.	Battle Mtn., Nev.	Utility	Altr.	1	115	700	4	7	9	4	S	S	....	.....
H. N. Noack & Sons	Arlington, Minn.	Cold Storage	Refrig. & Altr.	1	112½	400	3	9½	14	4	S	S	0.40	.....
				1	75		2							
Rutherford Mllg. Co.	Rutherford, Tenn.	Mill	Mill	1	112½	400	3	9½	14	4	S	S	0.40	.....
R. C. Meeks Estate	Allenwood, Pa.	Feed Mill	Mill	1	112½	400	3	9½	14	4	S	S	0.40	.....
J. J. Massey	Manila, Ark.	Plt. Pr.	Shaft	1	112½	400	3	9½	14	4	S	S	....	.....
New England Wrhs. Co.	Boston, Mass.	Plt. Pr.	Gen. & Shaft	1	112½	400	3	9½	14	4	S	S	....	.....
San Carlos Hotel	Yuma, Ariz.	Refrig.	Gen.	2	110	360	2	12	15	2	S	S	0.39	10.3
Peerless Glass	Long Island City, N. Y.	Plt. Pr.	Air Comp.	2	110	257	1	17	19	4	S	S	0.40	.....
Southern Service Co.	Florida	Ice Mfg.	Am. Comp.	1	110	257	1	17	19	4	S	S	0.40	.....
U.S. Indian Service	Valentine, Ariz.	Lt. & Power	Gen.	1	110	360	2	12	15	2	S	S	....	11.13
Serve-Ice Corp.	Mt. Kisco, N. Y.	Plt. Pr.	Am. Comp.	1	110	257	1	17	19	4	S	S	0.40	.....
Wilson Cold Storage	Wilson, N. Y.	Plt. Pr.	Am. Comp.	1	110	257	1	17	19	4	S	S	0.40	.....
Covert Baking Co.	Middleport, Ohio	Refrig.	.....	1	110	360	2	12	15	2	S	S	0.42	.....
Standard Fruit Co.	Honduras	Irrigation	Pump	1	110	257	1	17	19	4	S	S	0.40	.....
News Publishing Co.	Wheeling, W. Va.	Plt. Pr.	Gen.	1	110	360	2	12	15	2	S	S	....	11.13
Peoples Pulpit	Staten Island	WBBR Radio	Altr.	2	100	400	3	9	12	4	S	S	0.44	11
				1	60	400	3	7½	10½	4	S	S		
West Branch Creamery Co.	Milton, Pa.	Plt. Pr.	Gen.	2	100	...	5	..	..	..	..	..	....	.....
					60	514	3	7½	10½	4	S	S	....	.....
Fairburn Ice & Coal Co.	Fairburn, Ga.	Ice Plt.	Gen.	1	100	514	4	8	10½	4	S	S	0.41	.....
				1	75	514	3	8	10½	4	S	S	0.41	.....
Columbia Water Co.	Columbia, Pa.	Plt. Pr.	Gen.	1	100	514	4	8	10½	4	S	S	0.41	.....
Green Bros.	Franklinton, La.	Plt. Pr.	Gen.	1	100	514	4	8	10½	4	S	S	0.41	.....
Milford Water Co.	Milford, Mass.	Pumping	Pumps	1	100	514	4	8	10½	4	S	S	0.41	.....
Nario Mercadoe Hijos	Guayanilla, P. R.	Pumping	Pumps	1	100	514	4	8	10½	4	S	S	0.41	.....
Alvah J. Nelson	Thomaston, Ga.	Plt. Pr.	Shaft	1	100	514	4	8	10½	4	S	S	0.41	.....
A. & J. F. Rioux	Cohoes, N. Y.	Plt. Pr.	Gen.	1	100	514	4	8	10½	4	S	S	0.41	.....
				1	50	514	2	8	10½	4	S	S	0.41	.....
Schram Bottling & Cream Co.	Farmington, Mo.	Plt. Pr.	Gen.	1	100	514	4	8	10½	4	S	S	0.41	.....
U. S. Engineers Depot	Delhi, Ohio	Priv. Pr.	Gen.	1	100	514	4	8	10½	4	S	S	0.41	.....
Wiggins Ice & Fuel Co.	.....	Ice Plt.	Shaft	1	100	514	4	8	10½	4	S	S	0.41	.....
Woodruff Bros. Ice Co.	Chillicothe, Ill.	Ice Plt.	Comp.	1	100	514	4	8	10½	4	S	S	0.41	.....
F. Pepe Macaroni Co., Inc.	Waterbury, Conn.	Plt. Pr.	Gen.	1	100	360	3	9	14	4	S	S	....	11
City of Columbia	Pa.	Mun. C.S.	Gen.	1	100	514	4	8	10½	4	S	S	0.41	.....
Commercial Iron & Metal Co.	Waterbury, Conn.	Scrap Iron	Baling Press	1	100	360	3	9	14	4	S	S	....	.....
Universal Studios	Hollywood, Calif.	Standby	Gen.	1	100	...	6	7	10	4	S	S	....	.....
South Huntington Water District	N. Y.	Mun. Water	Pump	1	100	168	4	5½	7	4	S	S	0.465	.....
C. E. Duff	Lakeview, Ohio	Quarry	Shaft	1	100	210	1	17½	24	2	S	S	....	.....
Center Moriches Ice & Cold Stge. Co.	Center Moriches, L. I.	Ice Plt.	Comp. & Gen.	1	100	450	3	9½	10½	4	S	S	0.42	.....
Henry Bolduc Ice Mfg. Co.	Fitchburg, Mass.	Ice Plt.	Comp. & Gen.	2	90	300	3	10	13	4	S	S	....	.....
				1	45	...	4	6½	8½	4	S	S	....	.....
Paterson Milk & Cream Co.	Paterson, N. J.	Plt. Pr.	Gen.	2	90	850	4	6½	8½	4	S	S	0.42	.....
Avondale Farms Dairy	Bethlehem, Pa.	Store	Gen.	2	81	900	8	5⅜	8	4	S	S	0.41	.....
				1	38	1,000	4							
Mrs. J. M. Murphy	Los Angeles, Calif.	Priv. Pr.	Gen.	2	75	514	3	8	10½	4	S	S	0.41	.....
Ainsworth Pure Ice Co.	Watseka, Ill.	Plt. Pr.	Shaft. & Gen.	2	60	514	3	7½	10½	4	S	S	....	.....
Carey, Baxter & Kennedy	Scranton, Pa.	Stripping	Comp.	2	55	330	1	12¾	14	4	S	S	0.42	.....
T. H. Davies & Co.	San Francisco, Calif.	Mining	Comp.	2	55	330	1	12¾	14	4	S	S	0.42	.....

Typical Small Diesel Plants

Owner	Location	Service	No.	Hp.	R.p.m.	No. Cyl.	Bore, In.	Stroke, In.
Bottinelli Mnmtl. Co., New London, Conn., Comp. & Gen.			1	90	500	3	6½	8½
Allied Barrel Wks., Oil City, Pa., Gen. & Shaft			1	90	275	1	13½	18
Catawba Ice Co., Conover, N. C., Shaft & Gen.			1	80	514	4	7½	10½
Maynard, Mass., Village, Wtr. Pumps			1	78	400	3	8½	12
H. H. Lysinger & Son, Bedford, Pa., Gen.			1	75	400	2	9½	14
Tulia Mllg. Co., Tulia, Tex., Shaft.			1	75	700	4	6½	9½
Norristown Water Co., Norristown, Pa., Pump			1	75	514	3	8	10½
Sessions Co., Inc., Enterprise, Ala., Peanut Shllg.			1	75	820	6	5½	8
Lindsey & Douthitt, Greenbrier, Ala., Gin Pwr.			1	70	700	4	6½	9½
JubaCty. Mill & Elev.Co.,Nephi, Ut., Flour Mill			1	70	700	4	6½	9½
Alan Barton, Odenton, Md., Gravel Pit			1	70	700	4	6½	9½
Roth Const. Co., Cascade, Minn., Rock Crshr.			1	70	700	4	6½	9½
Cambridge Inst. Co., New York, N. Y., Gen.			1	70	700	4	6½	9½
Ed. F. Hickey's Sons, Inc., Winsted, Conn., Gen.			1	65	300	3	8½	12½
Keedysville Mllg.Co., Keedysville, Md., Flour Mill			1	65	700	3	7	9
Chestnut Ridge Dairy Co., Akron, Ohio, Gen.			1	60	514	3	7½	10½
Atlantic Ore Co., Juana Diaz, P.R., Shaft.			1	60	375	..	10½	10½
SavannahCold Storage, Savannah, N.Y., Shaft.			1	55	330	1	12½	14
Trenton Packing Co., Trenton, N. J., Am. Comp.			1	52	1000	3	5½	8
Milford Center Mllg. Co., Milford Ctr., O., Flour			1	50	300	1	13	17
Sr. Genaro Cautino, Guayama, P. R., Pump			1	50	514	2	8	10½
Weida's Inc., Paterson, N. J., Gen.			1	50	1200	6	4	5½
Eagle Rock (Va.), Mllg. & Mfg. Co., Flour & Ice.			1	50	850	4	5½	8
City of Plymouth, Ind., Pump			1	50	514	2	8	10½
J. H. Good, Woodson, Tex., Am Comp.			1	45	425	1	11¾	12½
Otterkill Ice Co., Salisbury Mills, N. Y., Altr. Comp.			1	38	1000	4	4½	5½
			1	27	1000	3	4½	5½
City of Las Animas, Colo., Pump.			1	37	850	3	5½	8
McNeil Cooperage, Rahway, N. J., Gen.			1	38	1000	4	4½	5½
Lt. Butt, Center Pt., Ind., Feed Grdr.			1	35	300	1	11½	16
Royal Pltg. & Plshg. Co., Newark, N. J., Gen.			1	30	400	1	10½	12
Paragon Steel & Tool, Rutherford, N. J., Gen.			1	27	1000	3	4½	5½
Ware Coupling & Nipple Co., Ware, Mass., Gen			1	25	514	1	8	10½
Allerton House, NewYork, N. Y., Am. Comp.			1	18	1000	2	4½	5½
Avondale Farms Dairy, Allentown, Pa., Gen.			1	18	1000	2	4½	5½
			1	9	1000	1	4½	5½
John Huss, Lakewood, N.J.		Apt. Hse. Lght.	1	18	1000	2	4½	5½
		Refrig.	1	5	1000	1	4½	5½
Glen Mere G. & P. Farm, Chester, N. Y., Pump			1	18	1000	2	4½	5½
LeBoeuf, Ltd., Springfield, Mass., Plt. Pwr.			1	16	1200	2	4½	4½
S. L. Fuller, Purchase, N. Y., Pump.			1	10	1000	2	4½	5½
G. H. Garman, Lehighton, Pa., Garage Pwr.			1	9	1000	1	4½	5½
			1	5	600	1	4½	5½
A. M. Wagenhorst, Mertztown, Pa., City Lghtg.			1	9	1000	1	4½	5½
Electro Mechano, Erie, Pa., Gen.			1	9	1000	1	4½	5½
Annex Dairy, New Haven, Conn., Comp.			1	8	1200	1	4½	4½
Tampa Grocery Co., Tampa, Fla., Store Comp.			5	5	600	1	4½	5½
Johnston Engrg. Corp., St. Petersburg, Fla., Pump			1	5	600	1	4½	5½
Diesel Lght. & Pwr. Co., Pendleton, Ore., Lghtg.			1	5	600	1	4½	5½
Sutton Mills, Sutton, Neb., Night Lght.			1	5	600	1	4½	5½

Typical New Gas Engine Installations

Plants Installed Since Jan. 1, 1933

Compiled by E. J. Tangerman
Assistant Editor

Owner	Location	Service	Horsepower	No. Engines	No. Cyl.	Bore, In.	Stroke, In.	R.P.M.	Single or Tandem	Horizontal or Vertical	Fuel Rate B.t.u. per Hp.-Hr.	Type of Fuel	B.t.u. per Cu. Ft. of Fuel
Panhandle Eastern Pipe Line Co.	Liberal, Kans.	Gas Comp.	1,000	5	4	21½	36	125	T.T.D.	H	10,000	Natural	1,020
Panhandle Eastern Pipe Line Co.	Louisburg, Kans.	Gas Comp.	1,000	5	4	21½	36	125	T.T.D.	H	10,000	Natural	1,020
Panhandle Eastern Pipe Line Co.	Glenarm, Ill.	Gas Comp.	1,000	4	4	21½	36	125	T.T.D.	H	10,000	Natural	1,020
United Gas Public Service Co.	Latex, Tex.	Gas Comp.	1,000	8	4	21½	36	125	T.T.D.	H	12,200	Natural	992 av.
Phillips Natural Gas Co.	Pampa, Tex.	Gas Pump	700	16	4	18½	20	200	T	H	10,000	Natural	1,050
Phillips Pipe Line Co.	Syracuse, Mo.	Pump	260	1	8	8	9	750	S	V	.....	Butane	3,200
Kettleman North Dome Assn.	Huron, Calif.	Pump	250	1	4	14½	17	257	S	V	10,000	Natural	1,000
Arrow Drilling Co.	Tulsa, Okla.	Gen.	250	2	6	8½	8½	900	S	V	11,000	Natural	1,000
Freeport Sulphur Co.	New Orleans, La.	Alt.	250	1	6	8½	8½	900	S	V	11,000	Gaso.	12,000 per lb.
Tulsa Ice Co.	Tulsa, Okla.	Power Plt.	240	3	8	9	11	450	S	V	10,500	Natural	1,050
Bay Towing Co.	Galveston, Texas.	Oil Pump	200	1	6	7	8½	900	S	V	11,000	Gaso.	12,000 per lb.
Phillips Petroleum Co.	Richmond, Kans.	Pump	200	1	6	8	9	750	S	V	.....	Natural	1,000
Panhandle Eastern Pipe Line Co.	Dodson, Mo.	Gas Comp.	180	1	..	..	..	180	T.S.	H	10,000	Natural	960
			90	1	..	..	..	180	S	H	10,000	Natural	960
Panhandle Eastern Pipe Line Co.	Paola, Kans.	Gas Comp.	185	3	2	18½	20	185	T.S.	H	10,000	Natural	960
Panhandle Eastern Pipe Line Co.	Stilwell, Kans.	Gas Comp.	185	3	2	18½	20	185	T.S.	H	10,000	Natural	960
Gulf Refining Co.	Neville Island, Pa.	Comp.	180	1	1	17	24	190	S	H	9,000	Ref. Gas.	1,650
National Petroleum Co.	Titusville, Pa.	Comp.	170	1	2	17	24	180	Twin	H	9,000	Natural	....
Heights Ice Co.	Houston, Texas.	Gen., Comp.	165	1	4	12¼	15	277	S	V	10,000	Natural	1,000
			65	1	2	11	12	327	S	V	10,000	Natural	1,000
Jaite Co.	Jaite, Ohio.	Gen.	130	1	4	11	12	327	S	V	10,000	Natural	1,000
Pilot Water Co.	Anaheim, Calif.	Pump	120	1	2	13	20	235	Dup.	H	10,500	Natural	1,140
			80	1	1	13	20	200	S	H			
Hermosa Water Co.	Alta Loma, Calif.	Pump	120	1	2	13	20	235	Dup.	H	10,500	Natural	1,140
Arena Mutual Irrigation Co.	Ontario, Calif.	Pump	120	1	2	13	20	235	S	H	10,500	Natural	1,140
Stephan Ice & Bottling Co.	Bryan, Texas.	Comp. & Gen.	110	1	4	10	12	327	S	V	10,000	Natural	1,000
			55	1	2	10	12	327	S	V			
Service Ice Co.	Paris, Texas.	Comp. & Alt.	110	1	4	10	12	327	S	V	10,000	Natural	1,000
Up to 100 Hp.													
Pennzoil Co.	Rouseville, Pa.	Hot-Oil Pump	90	1	1	17	24	200	S	H	9,000	Natural	900–1150
		Hot-Oil Pump	75	1	6	6	9	560	S	V	11,500	Natural	1600–1700
		Hot-Oil Pump	40	1	3	6	9	600	S	V	11,500	Ref.	1,650
Garden City Ice Co.	Garden City, Texas.	Comp. & Alt.	90	1	2	13½	15	277	S	V	10,000	Natural	1,000
Liebmann's Independent Ice Co.	Muskogee, Okla.	Comp. & Alt.	90	2	2	13½	15	277	S	V	10,000	Natural	1,000
Marathon Oil Co.	Bristow, Okla.	Hot-Oil Pump	80	2	1	17	24	170	S	H	9,000	Natural	900–1150
Conroe Ice Co.	Conroe, Texas.	Comp. & Alt.	80	1	2	12¼	15	277	S	V	10,000	Natural	1,000
			65	1	2	11	12	327	S	V			
Calhoun Ice Co.	Calhoun, Ga.	Integral Comp.	79	1	3	9	10½	450	S	V	9,700	Natural	1,000
Independent Ice & Refrg. Co.	Tulsa, Okla.	Comp. & Alt.	65	2	2	11	12	327	S	V	10,000	Natural	1,000
			40	1	2	8½	9	400	S	V	10,000		
Fairmount Creamery Co.	Dodge City, Kans.	Comp.	65	1	2	11	12	327	S	V	10,000	Natural	1,000
D. M. Jones	Ardmore, Okla.	Comp. & Alt.	65	2	2	11	12	327	S	V	10,000	Natural	1,000
Pampa Ice Mfg. Co.	Pampa, Texas.	Comp. & Alt.	65	1	2	11	12	327	S	V	10,000	Natural	1,000
Ada Ice Co.	Ada, Okla.	Comp. & Alt.	65	2	2	11	12	327	S	V	10,000	Natural	1,000
Double Dip Ice Cream Co.	Victoria, Texas.	Comp.	55	1	2	10	12	327	S	V	10,000	Natural	1,000
Burden-Smith & Co.	Macon, Ga.	Alt.	55	1	2	10	12	327	S	V	10,000	Natural	1,000
			40	1	2	8½	9	400	S	V	10,000	Natural	1,000
Peoples Gas Co.	Wilkinsburg, Pa.	Alt.	54	1	4	6	9	600	S	V	11,500	Natural	1,000
Oceania Oil Co.	Signal Hill, Calif.	Pump	50	1	1	12¼	20	235	S	H	10,500	Natural	1,140
Standard Oil Co. of Kansas	East Texas.	Pump Rig	27	2	2	6	9	600	S	V	11,500	Natural	1,500

Abbreviations

T.T.D.—Twin-tandem, double-acting
T.S. —Twin single
T. —Tandem
S. —Single; D.—Duplex
V. —Vertical
H. —Horizontal
Gen. —Generator
Alt. —Alternator
Comp.—Compressor

Important Hydro Plants in U. S. and Canada

Compiled By A. V. Karpov
Designing Engineer
Aluminum Company of America

Company	State	Project	River	Plant Capacity 1,000 Hp. Ultimate	Plant Capacity 1,000 Hp. Installed or being Installed	Date of Initial Operation	No. of Units Installed	Waterwheel Capacity, Ea., 1,000 hp.	Rated Head, Ft.	Type of Waterwheel	Speed R.P.M.	Generator Capacity, Ea., 1,000-K.V.A.	Power Factor
New England													
Connecticut Lt. & Pr. Co.	Conn.	Rocky River(c)	Rocky	66.6	33.3	1928	1	33.3	230	V.F.	200	30	0.80
Connecticut River Pr. Co.	N. H. & Vt.	Comerford	Conn.	216	216	1930	4	54	170	V.F.	138.5	39	0.90
Central Maine Pr. Co.	Me.	Wyman	Kennebec	102	68	1931	2	34	135	V.F.	138.5	26.7	0.90
Middle Atlantic													
Niagara Falls Pr. Co.	N. Y.	Schoellkopf	Niagara	452.5	452.5	1924	3	70	215	V.F.	107.1	65	0.80
						1920	3	37.5	215	V.F.	150	32.5	0.80
						1907	6	10	215	H.F.	300	7.2	0.90
							7	10	215	H.F.	300	8	0.80
Safe Harbor Water Pr. Corp.	Pa.	Safe Harbor	Susquehanna	510	261	1931	6	42.5	55	V.K.	109.1	36	0.80
							2	3.1	55	V.F.	180	2.5	0.70
							5a	13.5	53	V.F.	93.8	13.75	0.80
Pennsylvania Water & Pr. Co.	Pa.	Holtwood	Susquehanna	158	158	1910	2	17	62	V.F.	115.4	12	1.00
							1	16.5	62	V.F.	93.8	12	1.00
							2	20	62	V.F.	94.7	15	0.80
West Penn. Power Co.	Pa.	Lake Lynn	Cheat	72	72	1926	4	18	81.5	V.F.	133.5	16	0.80
South Atlantic													
Susquehanna Elec. Co.	Md.	Conowingo	Susquehanna	594	378	1928	7	54	89	V.F.	81.8	40	0.90
Lexington Water Pr. Co.	S. C.	Saluda	Saluda	330	220	1930	4	55.6	180	V.F.	138.5	40.6	0.80
New Kanawha Pr. Co.	W. Va.	Hawks Nest	New	175	140	1934	4	35	157	V.F.	150	30	0.85
Carolina Pr. & Lt. Co.	N. C.	Waterville	Big Pigeon	147	147	1930	3	49	755	V.F.	400	45	0.80
Carolina Pr. & Lt. Co.	N. C.	Norwood	Yadkin	118.9	87.8	1928	2	31.1	70	V.F.	90	27.5	0.80
							1	25.6	70	V.F.	90	22.5	0.80
Carolina Aluminum Co.	N. C.	Narrows	Yadkin	108	108	1917	4	27	165	V.F.	154	18	0.95
Carolina Aluminum Co.	N. C.	Cheoah	Little Tenn.	96	96	1919	4	24	180	V.F.	171.5	20	0.90
Georgia Power Co.	Ga.	Tallulah Falls	Tallulah	108	108	1913	6	18	608	V.F.	514	12	1.00
Georgia Power Co.	Ga.	Tugalo	Tugalo	88	88	1923	4	22	150	V.F.	171.4	12.5	0.90
East South Central													
Tennessee Valley Auth (U. S.)	Ala.	Muscle Shoals	Tennessee	610	260	1925	4	30	92	V.F.	100	25	0.80
							4	35	92	V.F.	100	32.5	0.80
Alabama Power Co.	Ala.	Jordan Dam	Coosa	216	144	1929	4	36	93	V.F.	100	29	0.86
Alabama Power Co.	Ala.	Martin Dam	Tallapoosa	180	135	1927	3	45	146	V.F.	120	37.5	0.88
Alabama Power Co.	Ala.	Lay Dam	Coosa	110	110	1914	4	17.5	70	V.F.	100	13.5	0.80
							1	19.5					
							1	20.5					
Alabama Power Co.	Ala.	Thurlow	Tallapoosa	84	84	1931	2	36	91	V.F.	100	29	0.86
							1	12	91	V.F.	180	10	0.80
Aluminum Co. of America	Tenn.	Calderwood	Little Tenn.	168	112	1930	2	56	213	V.F.	150	45	....
Louisville Gas & Elec. Co.	Ky.	Ohio Falls	Ohio	135	108	1928	8	13.5	37	V.P.F.	100	12.5	0.80
West North Central													
Union Elec. Lt. & Pr. Co.	Mo.	Bagnell	Osage	268	201	1931	6	33.5	90	V.F.	112.5	23.8	0.90
							1	3	90	V.F.	327	....	....
Mississippi River Pr. Co.	Iowa	Keokuk	Mississippi	300	155	1915	15	10	....	V.F.	57.7	9	....
							2	2.5	....	V.F.	....	2	....
Arkansas Pr. & Lt. Co.	Ark.	Carpenter	Ouachita	118.5	79	1931	2	39.5	89	V.F.	94.7	31.1	0.90
Mountain													
U. S. Bureau of Reclamation	Nev. & Ariz.	Boulder	Colorado	1,835	515	1935	4	115	520	V.F.	150	82.5	1.00
							1	55	520	V.F.	257	40	....
Montana Power Co.	Mont.	Volta	Missouri	84	84	1916	6	14	150	V.F.	200	10	0.80
Pacific													
City of Seattle	Wash.	Diablo	Skagit	320	166	1935	2	83	327	V.F.	171.5	66.7	0.90
Inland Pr. & Lt. Co.	Wash.	Ariel	Lewis	220	55	1931	1	55	185	V.F.	120	56.2	0.80
							1	1	185	V.F.	750	....	....
Puget Sound Pr. & Lt. Co.	Wash	Rock Island	Columbia	210	84	1933	4	21	32	V.P.A.	100	16.6	0.90
Great Western Pr. Co.	Calif.	Bucks Creek(b)	Feather	70	70	1928	2	35	2,561	H.P.	450	25	0.80
Great Western Pr. Co.	Calif	Caribou	Feather	180	90	1921	3	30	1,149	H.P.	171.4	22.2	0.90
Great Western Pr. Co.	Calif.	Big Bend	Feather	145	109	1908	4	18	465	V.F.	400	10	1.00
							2	18.5	465	V.F.	400	12.5	0.80
Chelan Electric Co.	Wash.	Chelan	Chelan	170	68	1927	2	34	377	V.F.	300	30	0.80
So. California Edison Co.	Calif	Big Creek No. 2	San Joaquin	88.5	88.5	1913	4	22.1	1,858	H.P.	375	17.5	0.80
So. California Edison Co.	Calif.	Big Creek No. 2A	San Joaquin	124.8	124.8	1928	2	62.4	2,418	H.P.	250	45	0.90
So. California Edison Co.	Calif.	Big Creek No. 3	San Joaquin	131.4	131.4	1923	3	43.8	830	V.F.	428	28	0.90
So. California Edison Co.	Calif.	Big Creek No. 1	San Joaquin	109.9	109.9	1913	3	22.1	2,131	H.P.	375	17.5	0.80
							1	43.6	2,131	H.P.	300	28	0.90
Portland General Electric Co.	Ore.	Oak Grove(d)	Clackamas	115	75	1931	1	35	850	V.F.	514	30	0.85
							1	40	850	V.F.	514	35	0.85
Hetch Hetchey Water Supply of San Francisco	Calif.	Moccasin	Tuolumne	100	100	1925	4	25	1,250	H.P.	257	20	....
Pacific Gas & Elec. Co.	Calif.	Pit No. 3	Pit	99	99	1925	3	33	454	V.F.	225	27	0.80
Pacific Gas & Elec. Co.	Calif.	Pit No. 1	Pit	80	80	1922	2	40	315	V.F.	257	35	0.80
Pacific Gas & Elec. Co.	Calif.	Tiger Creek	Mokelemne	72	72	1931	2	36	1,190	H.P.	225	30	0.85
City of Los Angeles	Calif.	San Fran. No. 1	Santa Clara	96.6	96.6	1928	3	32.2	940	H.P.	143	25	0.80
Canada	**Province**												
Alcoa Power Co.	Que.	Chute à Caron	Saguenay	1,060	260	1931	4	65	165	V.F.	120	56.2	0.90
							5	53	80	V.F.	75	46.6	0.80
Beauharnois Lt., Ht. & Pr. Co.	Que.	Beauharnois	St. Lawrence	2,250	546	1932	5	53	80	V.F.	75	43.8	0.85
							2	8	80	V.F.	180	7.2	0.80
Hydro-Elec. Pr. Comm. of Ont.	Ont.	Queenston	Niagara	565	565	1922	10	56.5	294	V.F.	187.5	55	0.80
Ottawa Valley Pr. Co. and Hydro-Elec. Pr. Comm. of Ont.	Ont.&Que.	Chats Falls	Ottawa	280	224	1932	8	28	53	V.P.F.	125	23.5	0.85
Duke-Price Power Co.	Que.	Isle Maligne	Saguenay	540	495	1925	11	45	110	V.F.	112.5	30	0.80
Hydro-Elec. Pr. Comm. of Ont.	Ont.	Abitibi Canyon	Abitibi	330	132	1932	2	66	237	V.F.	150	48.5	0.85
Gatineau Power Co.	Que.	Chelsea	Gatineau	170	136	1927	4	34	96	V.F.	....	35	0.80
Gatineau Power Co.	Que.	Paugan Falls	Gatineau	272	238	1928	7	34	132	V.F.	125	28.5	0.85
Gatineau Power Co.	Que.	Farmers Rapids	Gatineau	120	96	1927	4	24	66	V.F.	....	24.5	0.80
Shawinigan Water & Pr. Co.	Que.	Rapide Blanc	St. Maurice	240	160	1934	4	40	108	V.F.	109.1	36	0.85
Shawinigan Water & Pr. Co.	Que.	La Gabelle	St. Maurice	152	152	1925	4	30	60	V.P.F.	120	....	....
							1	32	60	V.P.F.	120	33	0.80
Shawinigan Water & Pr. Co.	Que.	Shawinigan Falls	St. Maurice	235	235	1912	5	20	145	H.F.	225	15	0.75
						1922	3	45	145	V.F.	138.5	40	0.75
Northwestern Power Co.	Man.	Seven Sisters	Winnipeg	225	112.5	1930	3	37.5	66	V.P.F.	138.5	32.5	0.85
Laurentide Power Co., Ltd.	Que.	Laurentide	St. Maurice	200	200	....	8	22	80	V.F.	112.5	25	0.80
							1	24	80	V.F.	....	....	....
British Columbia Pr. Co.	B. C.	Ruskin	Stave	188	47	1930	1	47	123	V.F.	120	44	0.80
Manitoba Power Co.	Man.	Great Falls	Winnipeg	168	168	1924	6	28	56	V.P.F.	138.5	21	0.90
MacLaren Quebec Pr. Co.	Que.	Masson	Lievre	136	136	1933	4	34	185	V.F.	166.7	28	0.85
St. John River Pr. Co.	N. B.	Grand Falls	St. John	80	80	1930	4	20	125	V.F.	163.6	17.5	0.90

V.F., Vertical-shaft francis; V.P.F., vertical-shaft propeller with fixed blades; H.F., horizontal-shaft francis; H.P., horizontal-shaft pelton; V.P.A., vertical-shaft propeller, with manually adjusted blades; V.K., vertical Kaplan with automatically adjusted blades. a, Double-runner units; b, highest head plant in North America; c, only important pumped-storage hydro plant in North America; d, highest head francis wheels outside of Europe.

GREAT machines in immense power plants set today's records of size and capacity, but the rising level of economic performance in plants large and small is even more significant for the future

MILESTONE

ONE — NINE — THREE — FOUR

WHATEVER the future may think of 1934 records and performance, it is worth while to set them down to refresh our own memories, and to erect a milestone from which our successors may measure power progress to 1944, 1954 and 1984.

What are the typical practices and performances of today? What are our ideas about power generation? What are the record power achievements?

Power Generation

1934 finds the majority of America's installed capacity in steam prime movers. Hydro-electric generation comes second, oil and gas plants third. Roughly, the 1934 division of installed capacity in horsepower is about as shown in Table I. To this must be added a certain unknown total capacity in farm and domestic prime movers.

Since the load factors of these plants differ, the power output is not in the same proportion as the installed capacity. No reliable data on the kilowatt-hour output of industrial plants are available. Table II, for central stations alone, shows that hydro turbines, with 28 per cent of the capacity, generate 41 per cent of the total energy.

These 1933 figures of Table II are not truly representative on account of the great depression which started with the stock-market collapse of October, 1929, and from which we are just now beginning to emerge. Hence, the 1928 figures are listed for comparison.

Table I does not give a fair picture of the relative importance of the industrial power plant, because most industrial plants supply a variety of power services in addition to electricity. The use of steam for process and heating makes installed kilowatts almost meaningless as a measure of industrial plant capacity. Whether process steam comes from boilers (direct) or from the bleed points or exhaust of prime movers, its extensive use greatly increases the plant ratio of boiler to prime-mover capacity. Steam-generating capacity, then, rather than installed kilowatts, is the practical measure of an industrial power plant.

No precisely dependable data on the installed boiler capacity of either central stations or industry are available, but a recent analysis indicates that industrial plants contain nearly five times as much boiler heating surface as all central stations. Their aggregate actual steaming capacity is probably double that of the central stations, after making ample allowance for the lower average peak ratings of industrial boilers.

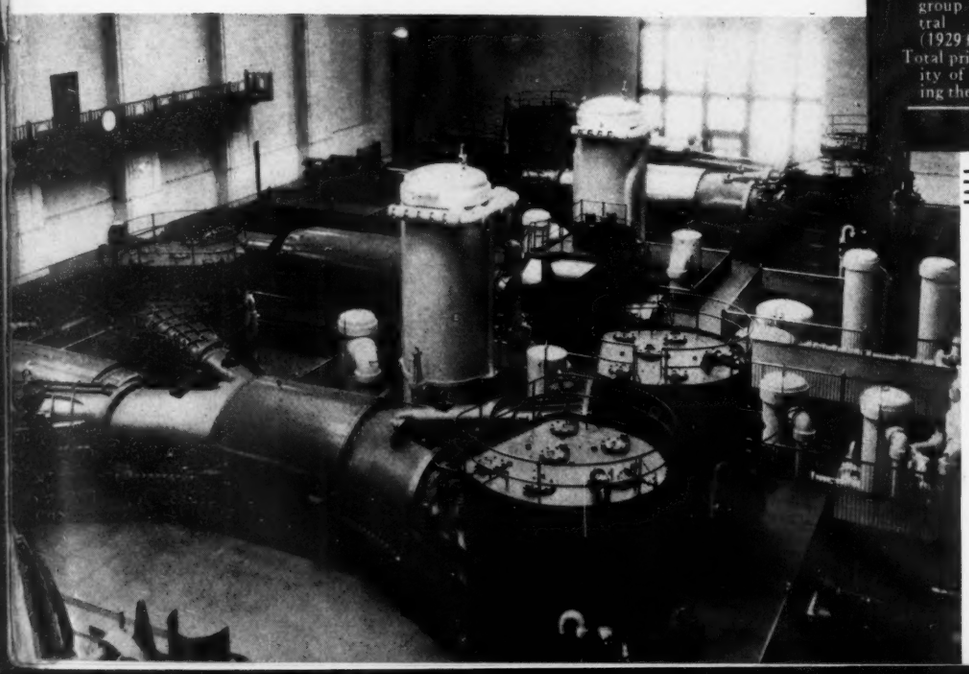
Industrial Boiler Room

What is typical power practice today? We may sum up the high spots very briefly for future readers.

First comes the boiler room. The modern boiler

Table 1—Prime Mover Installed Capacity (Millions of Horsepower or Kilowatts)

	Steam	Hydro	Internal Combustion	Total
A—Central Stations (Including Municipal) Kilowatts	33.7	13.6	0.9	48.2 (34.1)
B—All Others, 1929 Figures (Mainly Industrial)	21.6	1.6	1.5	24.7
Total	55.3	15.2	2.4	72.9
Additional motors in group B driven by central station energy (1929 figures)				27.6
Total prime mover capacity of group B, including these motors				52.3



World's largest turbine, 208,000-Kw., State Line Station, Chicago District Electric Generating Corp.

Ewing Galloway

room is fired by coal, oil, natural gas, waste fuels—important in the order named. Coal is mechanically stored, handled and weighed in ways too numerous to mention. It generally ends up in an overhead bunker, from which it flows to stoker hoppers, or to a traveling larry delivering to the hoppers. Principal stoker types are underfeed, overfeed, traveling grate.

Pulverized coal is handled and prepared by the "unit system," which has one or more pulverizers feeding each boiler directly, or by the "central system," in which a group of pulverizers deliver coal to storage, from which it is delivered to boilers. Oil burners effect atomization mechanically or by steam or compressed air.

Boiler furnaces are lined with solid refractory, air-cooled refractory, water-cooled walls, or any combination of the three. The boiler (except in very small plants) is generally a water-tube unit, horizontal-tube header type, or inclined-tube multi-drum. Steam is generated at any pressure up to 1800 lb. Only one boiler in America operates commercially at that pressure, and not many in the 1200-1400-lb. range. Typical steam temperatures for modern central stations run from 700 to 850 deg. F., with a trend toward 850 deg.

Most industrial plants operate non-condensing, and therefore do not require such high steam temperatures. Steam temperatures in industrial plants rarely exceed 700 deg., and are generally under 600 deg.

Central-station boilers of the latest type fall mainly in one of the two special groups: 300 to 500 lb. without reheating, 1200 to 1400 lb. with reheating. Most industrial boilers still carry less than 300 lb. pressure, but many recent installations range from 300 to 600 lb.

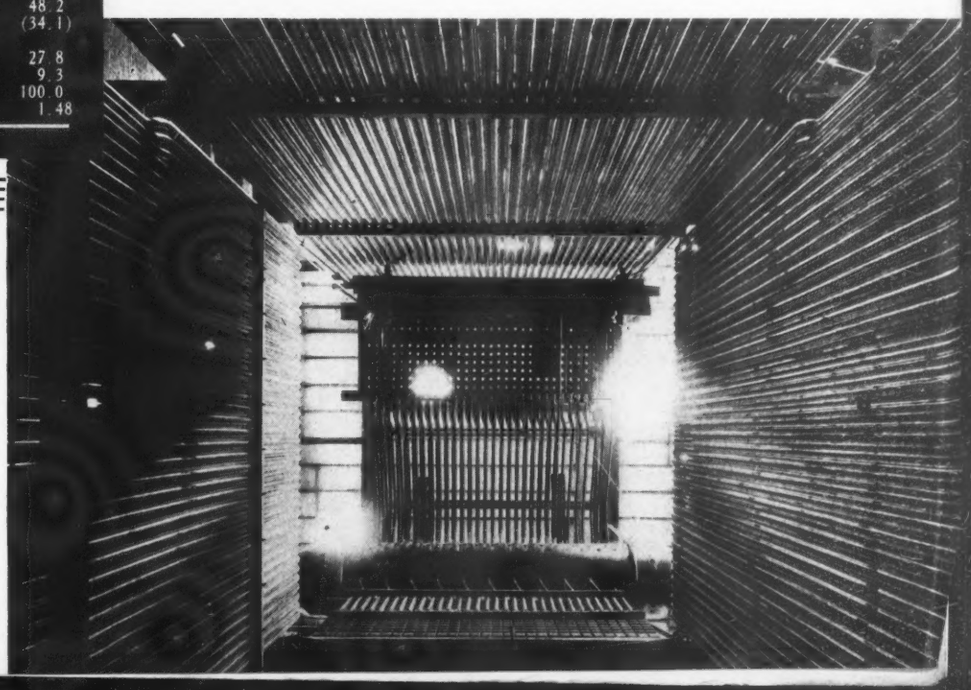
The modern boiler room is equipped with indicating and recording pressure and temperature indicators, flow-meters, CO_2 recorders and other scientific aids to economical operation. Many of the more recent plants are equipped with automatic combustion control, maintaining constantly the best proportions of air and fuel. All good plants heat the boiler feed water in one or more stages. Feed pumps are more frequently centrifugal, driven by motors or turbines. Feed-water softeners, hot-process lime-and-soda, also zeolite, are widely used, in addition to evaporators and direct addition of chemicals to the boiler water. The use of continuous blow-down with heat recovery is growing.

Other equipment found in many modern boiler plants includes forced and induced-draft fans, economizers, air preheaters, soot blowers, feed-water regulators, non-return valves. The boiler room is no longer typically a place of heat and heavy labor. Brains have largely replaced brawn.

Boiler-room efficiencies rise above 90 per cent in a few cases; 80 per cent is common in first-class plants, while 70 per cent boiler-room efficiency is considered only fair even for small industrial plants.

Table 2—Central Station Operating Totals and Averages

	1928	1933
Capital Invested, Billions	$10.3	$12.8
Revenue, Billions	1.94	1.92
Output, Billions of Kw.Hr.		
From Fuel	49.4	47.2
From Hydro	33.5	32.8
Total	82.9	80.0
Ratings, Millions of Hp.		
Steam Engines & Turbines	27.4	33.7
Water Turbines	11.1	13.6
Internal Combustion Engines	0.6	0.9
Total	39.1	48.2
(Total Kw.)	(27.7)	(34.1)
Fuel Consumption		
Coal & Coke, Millions of Tons	37.6	27.8
Oil, Millions of Barrels	6.8	9.3
Gas, Billions of Cu. Ft.	77.0	100.0
Coal Rate, Lb. Per Kw.Hr.	1.76	1.48



Highest U. S. Pressure, 1,800-lb. at boiler drum. Looking up through the Philip Carey plant water walls.

Prime Movers

In steam-electric central stations, generation of electricity is almost invariably by steam-turbine generators, bled at several points for feed heating and exhausting to surface condensers. Some of the large industrial plants, particularly where small amounts of process steam are required, operate condensing. More commonly, such plants operate turbines or engines exhausting or bleeding steam for heating and process.

Steam engines are widely used in industrial installations, and many new installations of uniflow engines are being made in those moderate sizes where the engine shows a lower steam consumption than a comparable turbine. The use of diesel engines is rapidly increasing for small municipal and private

central stations, and for industries using little process steam. Replacements of obsolete private-plant generating units by purchased utility current still continue, but are approximately counterbalanced by efficient new industrial installations. Important factors in this trend are the great technical improvements in design of industrial power plants. Higher steam pressures, particularly, enable some industrial plants to generate their entire power load as a by-product of process and heating steam.

Industrial pumping is now taken care of mainly by centrifugal pumps driven by motors or turbines. Compressed air is produced generally by piston compressors, either one- or two-stage, driven by engines or synchronous motors.

Many systems of refrigeration are in operation, the ammonia-compression system being most common. In the last year or two vacuum water refrigeration has come rapidly to the front, chiefly for the moderate temperatures required in air conditioning. The applications of air conditioning (involving humidification, dehumidification and cooling) have rapidly increased.

The art of heating and ventilating has been constantly improved. Today building heat is supplied by direct steam, hot water, steam under regulated vacuum, hot air. Wide use is made of zoning, orifice control, thermostats, and other devices for better service and greater economy in heating. A few heating plants utilize the reversed-refrigeration cycle.

Mechanical power transmission has become more scientific and is gaining new recognition. Gears, speed reducers, V-belts, flat belts, have been greatly improved. A present trend back to group drive in many instances is noted.

POWER RECORDS OF 1934

Only equipment in commercial operation is listed, except where otherwise indicated

Steam-Electric Stations

LARGEST: 770,000-kw., Hudson Ave. Sta., Brooklyn (N. Y.) Edison Co.
HIGHEST PRESSURE (U. S.): About 1,800 lb. at boiler drum, engine prime movers, Philip Carey Co., Lockland, Ohio.
LARGEST CAPACITY HIGH-PRESSURE BOILER: 750,000 lb. per hr. peak at 1,400-lb. pressure, Ford Motor Co., River Rouge Plant.
HIGHEST STEAM TEMPERATURE: 1,000 deg., Delray No. 3, Detroit Edison Co. (one 10,000-kw. unit).
LARGEST CAPACITY BOILER (U. S.): 1,270,000 lb. per hr. peak, Fourteenth St. (New York), N. Y. Edison Co.
LONGEST AND HIGHEST CAPACITY UNDERFEED STOKER: 694 sq.ft. projected area, Hudson Ave., Brooklyn (N. Y.). Edison Co.
LARGEST COAL PULVERIZER: 50 tons per hr., Kips Bay, N. Y. Steam Co.
HIGHEST COAL COMBUSTION RATE: 85 lb. per sq.ft. of grate area per hr.; Hudson Ave.
HIGHEST FURNACE HEAT-LIBERATION RATE: 890,000 B.t.u. per cu.ft. per hr., oil-fired pressure-combustion furnace, Brown Boveri Steam Turbine Works.
LARGEST TURBINE: 208,000-kw., 3-cyl. unit; State Line, Chicago District Electric Generating Corp.
LARGEST SINGLE-SHAFT TURBINE & GENERATOR: 160,000-kw. turbine, 200,000-kva. (at 80 per cent p.f.) generator (world's largest), 2 identical units, Hudson Ave., Brooklyn (N. Y.) Edison Co.
LARGEST 3,600-R.P.M. TURBINE: 18,000 kw., Burlington (N. J.), Public Service Electric and Gas Co.
LARGEST HIGH-PRESSURE TURBINE: 110,000-kw.; 1,200-lb. steeple-compound unit; Rouge plant; Ford Motor Co.
LARGEST CONDENSERS: 101,000-sq.ft., 2 units of different make and design; Hudson Ave., Brooklyn (N. Y.) Edison Co.
HIGHEST GENERATOR VOLTAGE (U. S.): 22,000 volts; State Line, Chicago District Electric Generating Corp.

Mercury-Steam-Electric Power Plants

ONLY COMPLETELY NEW PLANT: Schenectady (N. Y.), owned by General Electric Co.
LARGEST MERCURY TURBINES AND MERCURY TURBINE INSTALLATIONS: 20,000 kw., 1 turbine each, Schenectady G.E. plant and Kearny plant of Public Service Electric and Gas Co., N. J.

District Steam Plants

LARGEST PLANT: 2,500,000 lb. steam per hr. capacity, Kips Bay, New York Steam Co.
LARGEST SYSTEM: 7,170,000 lb. steam per hr. capacity, 5 plants, delivered 11,430,339,000 lb. steam in 1933; New York Steam Co.

Hydro-Electric Units, Plants

LARGEST PLANT: 756,000 hp. (normal); Dnieperstroy, U. S. S. R., (Beauharnois on St. Lawrence designed for 2,250,000 hp. ultimate).
LARGEST TURBINES: Nine 84,000-(normal) hp. units; max. over 100,000 hp.; Dnieperstroy, U. S. S. R. (Four 115,000-hp. units being built for Boulder Dam, Colorado River).
HIGHEST DAM: 730 ft. high (under construction) producing largest artificial lake, Boulder Dam.
LARGEST PLANT (U. S.): 452,500 hp.; Schoellkopf, Niagara Falls Power Co.
LARGEST TURBINES (WESTERN HEMISPHERE): Three 70,000-hp., Schoellkopf plant.
HIGHEST HEAD IMPULSE WHEEL: 5,715 ft.; Dixence, Switzerland.
HIGHEST-HEAD IMPULSE WHEEL (WESTERN HEMISPHERE: 2,561 ft. effective; Bucks Creek, Great Western Power Co. (Cal.).
HIGHEST-HEAD FRANCIS-TYPE WHEEL: 1,180 ft., Zappelo plant, Italy.
HIGHEST-HEAD FRANCIS-TYPE WHEEL (WESTERN HEMISPHERE): 935 ft. (static), effective 850 ft.; Oak Grove Plant, Portland (Ore.) General Electric Co.
LARGEST KAPLAN-TYPE WHEELS: Six 42,500-kw. units, Safe Harbor (Pa.), Safe Harbor Water-Power Corp.
HIGHEST-HEAD KAPLAN-TYPE WHEELS: 106 ft. max., River Shannon plant, Ireland.
HIGHEST-HEAD KAPLAN-TYPE WHEELS (WESTERN HEMISPHERE): 52 ft., Safe Harbor.
LARGEST PUMPED-STORAGE PLANT: Four 49,500-hp. units of pump, turbine and generator-motor; Herdecke plant, Ruhr River, Germany.

Diesel and Gas Plants

LARGEST DIESEL PLANT: 51,200 hp., French Concession, Shanghai, China.
LARGEST DIESEL PLANT (U. S.): 35,000 hp., Municipal, Vernon, Cal.
LARGEST PRIVATE UTILITY DIESEL PLANT (U. S.): 11,600 hp., Tucson (Ariz.), Tucson Gas, Elec. Light & Power Co.
LARGEST DIESEL ENGINE: 22,500 hp., Municipal, Copenhagen, Denmark.
LARGEST GAS ENGINES: Four 10,000-hp. units driving generators, S. Chicago plant, Illinois Steel Co.

Miscellaneous

HIGHEST CAPACITY PUMPS: Three 36,600-hp. units, 240,000 g.p.m. against 479-ft. head, Herdecke pumped-storage plant, Ruhr River, Germany.
LARGEST AMMONIA COMPRESSOR: 2,700 tons (2,200-hp. drive), Winterschell Trust, Merkers Works, Germany.
LARGEST STEAM-JET REFRIGERATING UNIT: 600 tons, Anheuser Busch Plant, St. Louis, Mo.
HIGHEST ROTATIVE SPEED: 1,250,000 r.p.m., Air-supported and air-driven centrifuge, Sharples Co. laboratory.
LARGEST PIPE: 30-ft. diameter welded steel pipe for Boulder Dam.

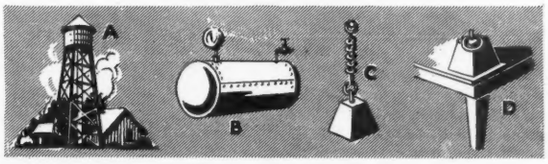
Energy ON PARADE

By PHILIP W. SWAIN

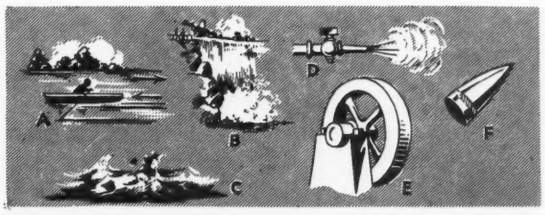
Editor of Power

Men, Money, Equipment, Energy! These four are the basic elements of power engineering, yet only the first three have passed in review on the pages of technical magazines. Who has ever lined up energy for inspection? So here they come: Forms of Energy; Transformations; Heat Engines; Unusual Power Plants—a parade of energy facts—a pageant of possibilities.

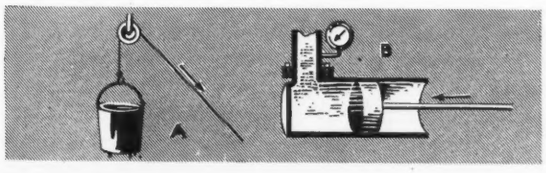
FORMS OF ENERGY



POTENTIAL ENERGY—Energy is the "capacity for doing work." Energy existing because of position or restraint is "potential energy." Prime examples: (A) Water stored with available head, (B) gas stored under pressure, (C) stretched spring, (D) weight held up above available level.

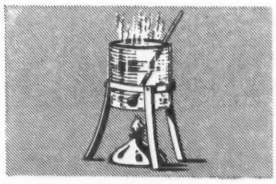


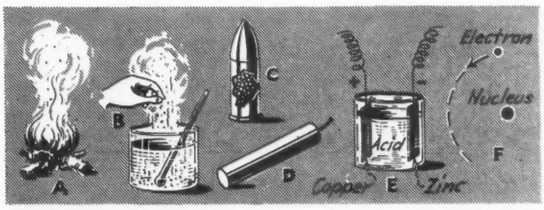
KINETIC ENERGY—A mass in motion can do work because of its "kinetic energy." Practical examples are the movement of water in streams (A), falls (B), tides, waves (C) and jets (D); the movement of air in wind and jets; the movement of heavy solids, notably the flywheel (E) and the projectile (F).



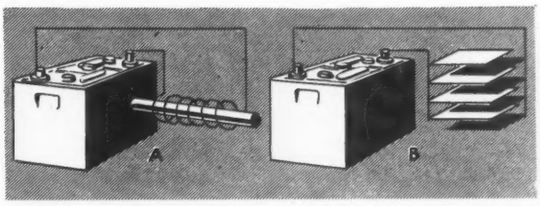
WORK—"Work" is done when a force acts through a distance in moving a body, as in lifting water bucket (A), or pushing pump piston (B).

HEAT—"Heat" is that which, when added, tends either to raise the temperature of a body or to change its physical or chemical state.



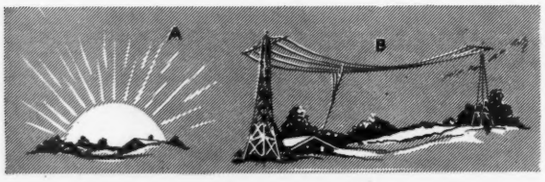


CHEMICAL ENERGY—"Chemical energy" takes many forms, (A) calorific, the ability to unite with oxygen and give off heat, (B) the ability to give off heat when dissolving in water (e.g., sulphuric acid), (C) the ability to give off heat or do work when combining with some other chemical, as with another constituent of gunpowder, (D) the ability of the atoms of a compound to recombine with production of work, e.g., dynamite, (E) galvanic energy, (F) energy within the atom due to position and rotation of electrons.



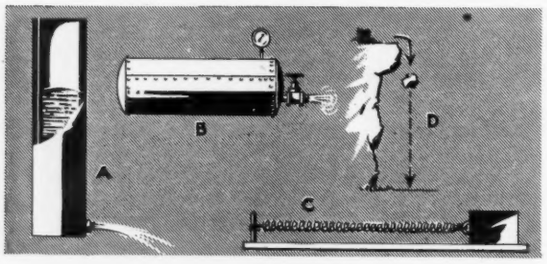
ELECTRICITY—Kilowatt hours of electricity are energy, unstorable as such, except that small amounts may be stored in the "inductance" (A) of a circuit,

or electrostatically in a condenser (B). Electricity "stored" in a storage battery is actually converted into chemical energy for later reconversion into electricity.

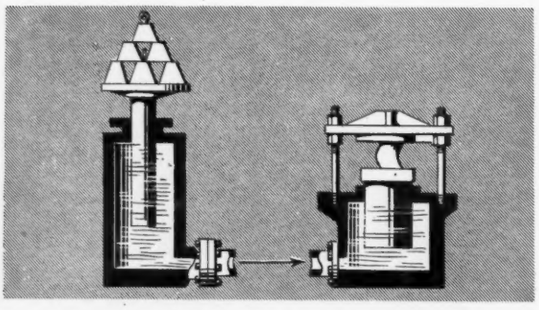


RADIATION—Radiation occurs in great variety, including air waves (sound) and streams of electrons (as from radium), but the most important is the electromagnetic radiation, so called "ether waves." The wave lengths radiated by the sun (A) comprise the complete range of visible waves ("light"), in addition to shorter waves (ultra-violet) and longer waves (infra red). Very much longer, but still basically the same are the waves radiated by the broadcast station (B). All electro-magnetic radiation travels at a speed of 186,000 miles per second.

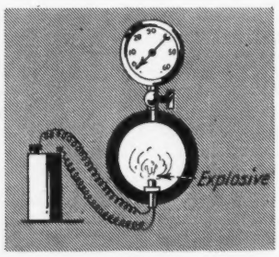
TRANSFORMATIONS OF ENERGY



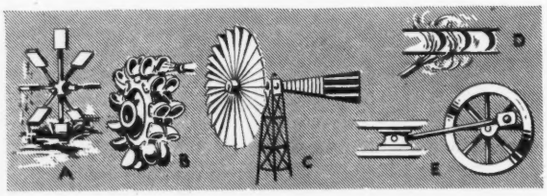
POTENTIAL TO KINETIC, KINETIC TO POTENTIAL—Potential energy (energy of position) can be changed to kinetic energy (energy of motion) in various ways. Notable in engineering are: (A) Production of water jet from pressure or head; (B) Same for air jet; (C) Speeding movement of a weight acted on by a stretched spring; (D) Boulder falling over edge of a cliff. All of these can be reversed.



POTENTIAL TO WORK, WORK TO POTENTIAL—Water head acting directly on a moving piston or plunger illustrates the change of potential energy into work. In the example shown, the potential energy, represented by the elevation of the weights on the accumulator plunger, is transmuted into work at the operating surface of the hydraulic press. This process is reversed by the hydraulic pump forcing the accumulator back up.

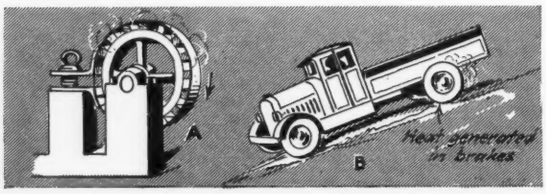


CHEMICAL TO POTENTIAL — The apparatus shown illustrates the conversion of chemical energy to potential. Explosive is detonated in a chamber strong enough to withstand the explosion. After gases have cooled off the gage cock is opened. Rise of gage reading demonstrates the presence of gas under pressure (i.e. potential energy) in bomb.



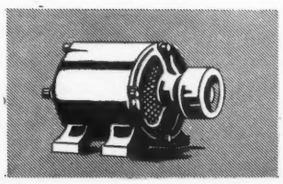
KINETIC TO WORK, WORK TO KINETIC—Conversions of kinetic energy to work are common. Examples are: (A) Energy of swiftly flowing stream to a "current" water wheel; (B) Energy of water jet to Pelton wheel; (C) Energy of moving air to wind mill; (D) Energy of steam jet to turbine wheel; (E) Energy of flywheel to shaft near end of engine stroke when piston fails to supply enough torque to keep up speed.

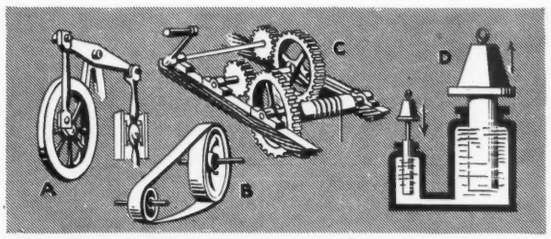
Reversing operation, (A) gives paddle wheel, (C) the propeller, while the flywheel (E) stores up energy from work early in the stroke.



KINETIC TO HEAT, WORK TO HEAT—When any object, moving by its own inertia only, is stopped by friction, as where flywheel (A) is braked, heat equivalent to the kinetic energy is generated. Other examples are braking of motor truck or train and gradual slowing down of a ship after engine is stopped. Similarly, a vehicle driven by power on the level at constant speed produces friction heat exactly equivalent to the work which is delivered by the driving engine. The same happens when truck (B) descends hill at constant speed. Work and heat are mutually convertible at the rate of 1 B.t.u. for 778 ft. lb.

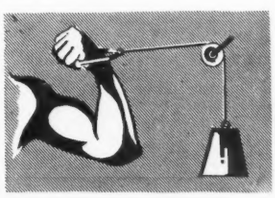
KINETIC TO ELECTRICAL —A good example is the generator. If belt drive slips off, flywheel effect of moving parts will deliver kinetic energy to produce electricity during the slowing-up period. This process is reversible. Electrical energy applied to a stopped motor, disconnected from its load, will produce a rapid speeding up, illustrating conversion of electricity to kinetic energy.



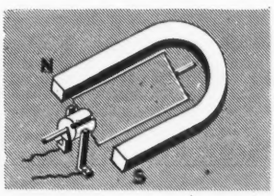


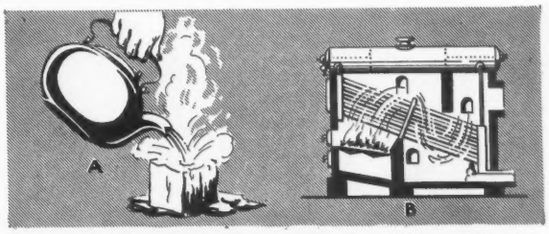
WORK TO WORK—Innumerable mechanical systems are used to transform work at one place to work at another place or to change work involving small force and large movement to the reverse. None of these devices can increase the *amount* of work. Because of friction, which converts part of the input to heat, each gives out less work than is put in. Typical arrangements for transforming work to work are: (A) Combinations of cranks, levers, links, connecting rods; (B) Belts and pulleys; (C) Gear trains; (D) Hydraulic pump and press.

CHEMICAL TO WORK— All animals, including man, constantly convert chemical energy directly to work through the medium of muscle fibre. Experiments show, the over-all efficiency (food to delivered work) of men or draft-animals compares favorably with that of a modern steam power plant. Nevertheless such power is decidedly "expensive." An average output of 1/15 kilowatt (equivalent) is high for a laboring man. At 50 cents per hour energy output costs $7.50 per kw.-hr.

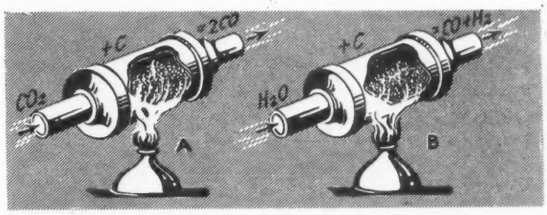


WORK TO ELECTRICITY, ELECTRICITY TO WORK —A conductor so moved as to cut the lines of force of a magnetic field generates an electromotive force which will produce a current of electricity in a circuit. The generator utilizes this principle to convert work into electricity. An electric current in a conductor in a magnetic field is pushed at right angles to field and conductor. The electric motor utilizes this principle to convert electricity into work. Work and electricity are mutually convertible at the rate of 1 kilowatt-hour for 2,656,000 foot-pounds.



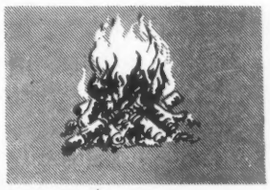


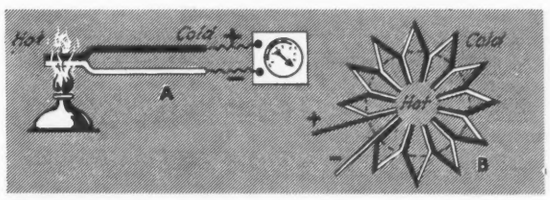
HEAT TO HEAT—Heat passes of itself from the hotter to the colder body. (A) Heat of hot water becomes latent heat of fusion of water melted from ice block. (B) Sensible heat of furnace gases becomes heat of liquid and vaporization of boiler steam.



HEAT TO CHEMICAL—In the so-called "endothermic" chemical reactions heat is soaked up to produce chemical energy. For example, in (A), CO_2 gas passed over hot carbon produces the combustible gas CO, but at the expense of heat which must be supplied to the carbon to keep it hot, since the reaction is "cooling." Likewise, in (B), steam passed over hot carbon produces CO and H_2. This is the well known water-gas reaction used in city gas works. Commercially the carbon is heated up by first burning part of it to CO_2, which is an "exothermic" reaction, giving off heat. It will be noted that the reactions of (A) and (B) are the exact opposite of burning. Literally they take a burned substance and "unburn" it into a combustible substance.

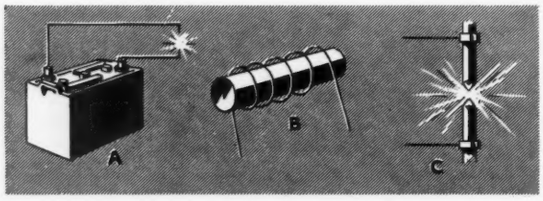
CHEMICAL TO HEAT— Of all energy transformations the change of chemical energy to heat is one of the most common. Notable example is the burning of fuels.



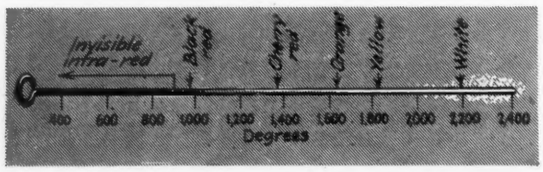


HEAT TO ELECTRICITY—The thermocouple (A), a heated junction of two dissimilar metals, widely used

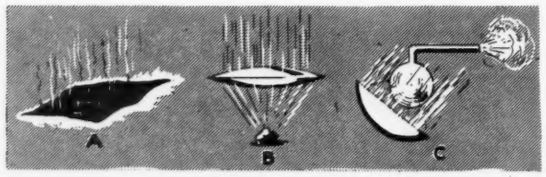
for temperature measurements, directly converts heat into electricity. Supposedly a furnace (B) heating thousands of junctions should yield electricity in appreciable quantities. So far as is known, little serious study is being given to this subject today by commercial groups.



ELECTRICITY TO HEAT—It is always easy to transform any other form of energy into heat, and with 100 per cent efficiency. Electricity may be turned directly into heat through (A) resistance, (B) eddy currents and magnetic hysteresis in an iron or steel core magnetized by an alternating current, (C) resistance of an arc. One kilowatt-hour equals 3,415 British thermal units.

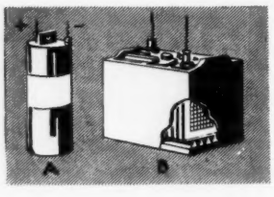


HEAT TO RADIATION—All hot bodies automatically emit electro-magnetic radiation. The wave-length distribution of that radiation for any temperature can be exactly predicted for a so-called "black body," which is approximated by ordinary dark objects. The hotter the object the whiter the color of the radiation and the shorter its average wave length.



RADIATION TO HEAT—Black cloth (A) on snow in bright sunshine absorbs heat from sun's radiation. To deliver its heat energy at higher temperature, or concentrate it in a smaller area, the radiation can be redirected by a convex lens or parabolic mirror as illustrated by the burning glass (B) and the sun-operated miniature boiler (C).

CHEMICAL TO ELECTRICITY—Conversion of chemical energy to electrical energy is common and commercial. Primary cell is widely applied in dry cells (A)

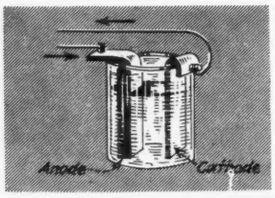


used for flash lamps, signals and ignition. Twenty-nine million storage batteries (B) are used in automobiles alone in United States. If these were all operated simultaneously at engine-starting load the total output would practically equal the entire central-station power generating capacity of the United States.

Actual electro-chemical efficiency of these units is high. The cost of original energy is a minor part of the cost of energy delivered. Labor, depreciation, etc., are much more important and may bring the total cost to 20c. per kilowatt-hour.

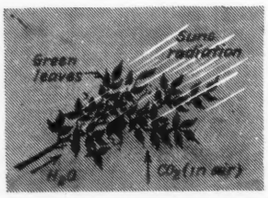
Attempts have been made to apply the high efficiency of primary cells to a low-cost energy source such as coal, using the coal as an electrode. Such experiments have been largely abandoned.

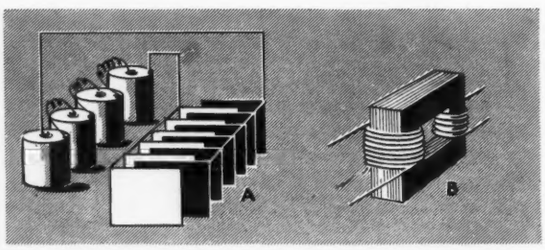
ELECTRICITY TO CHEMICAL — Direct current, passed from an "anode" through an "electrolyte" to a "cathode," produces chemical changes which may or may not store up chemical energy.



For example, the ordinary copper plating operation is an operation of zero efficiency since no chemical energy is stored up. The net result is merely the transfer of metallic copper from one place to another. All energy supplied is converted into heat. At the other extreme is the storage battery wherein about 70 per cent of the electrical energy supplied is stored up as chemical energy.

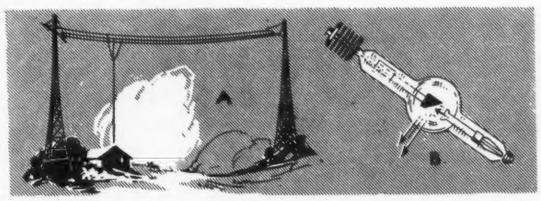
RADIATION TO CHEMICAL—An example is furnished by all green vegetation. In some mysterious way the chlorophyl (green substance) of leaves is part of the machinery that converts the burned hydrogen in water and the burned carbon in atmospheric CO_2 back into the burnable substance of the vegetation. The process is the reverse of combustion. Thus the energy of coal is really sun's radiation stored in the green vegetation of millions of years ago.





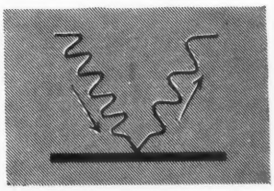
ELECTRICITY TO ELECTRICITY—Electricity as such cannot be stored except as "static" and, practically, in rather small quantities. Condenser in (A) will

store only minute electrical energy even with many plates and fairly high voltage. (B) Transformer changes alternating current of one voltage and amperage to another voltage and amperage, but never increases the energy.



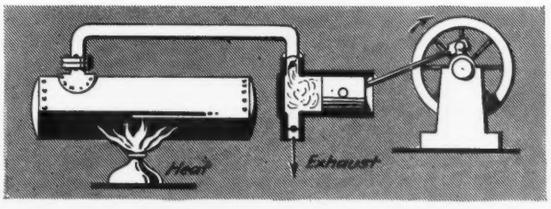
ELECTRICAL TO RADIATION, RADIATION TO ELECTRICAL—By means of "wireless" (A) or X-Ray tube (B) electrical energy may be converted directly to radiation. The incandescent light, arc light and electric spark convert electrical energy to heat, which is in turn immediately turned into radiation, of which a portion (called light) is visible.

General engineering opinion is today still skeptical of the commercial practicability of transmitting power in substantial quantities by wireless. Progress has, however, been made in the perfection of sharply defined radio beams for this possible use among others. Stations broadcasting in all directions deliver only an infinitesimal fraction of their power to receivers. A typical household radio receiving set 100 miles from a 5,000-watt broadcasting station actually picks up about one-billionth of a watt or one fifty-billionth of one per cent of the power broadcast.



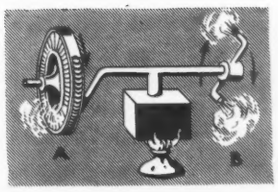
RADIATION TO RADIATION — Under certain conditions, electro-magnetic radiation of one wave length, striking a surface, will result in emission of waves of another length. Thus certain fluorescent paints will emit visible color if exposed to the invisible ultra-violet rays.

HEAT ENGINES

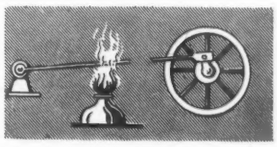


STEAM ENGINE—Steam expanded behind a moving piston from a higher to a lower pressure is, historically, the most important method of generating power, but exceeded today in energy output by the steam turbine.

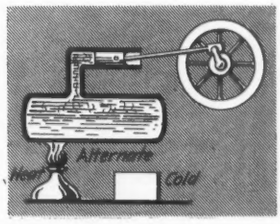
The steam engine and turbine have the same theoretical efficiency limits.



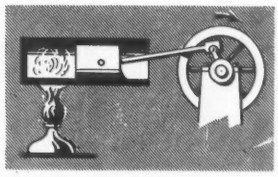
STEAM TURBINE—The steam turbine expands steam from one pressure to another and generates power with the same theoretical efficiency as the steam engine. In the "impulse" turbine (A), expansion is in stationary nozzles directing the steam jets onto the moving blades. In (B) is diagrammed the pure reaction turbine in a simplification of its historic form, Hero's engine. Expansion in moving blades or nozzles characterizes the reaction turbine. The steam turbine is today the most widely used prime mover for large scale power generation.



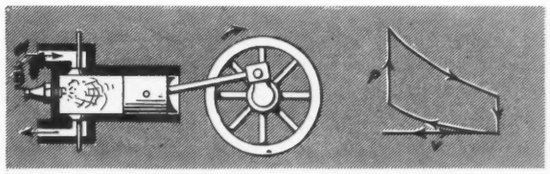
METALLIC-EXPANSION ENGINE — If a long metal rod is alternately heated and cooled, its resulting expansion and contraction can be made to turn a shaft by means of a crank or similar mechanism. This type of engine has no engineering standing at the present time.



LIQUID-EXPANSION ENGINE—By alternate heating and cooling of the mass of water in the pressure vessel, its expansion and contraction can operate a small piston and crank. This engine has the same theoretical efficiency limits as any other heat engine. With perhaps one exception, few modern engineers have given it consideration.

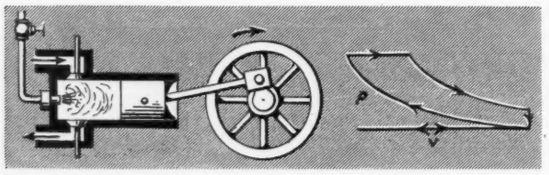


HOT-AIR ENGINE—Air is alternately heated and cooled by external sources to operate a reciprocating piston. This engine has a high theoretical efficiency. It has been used for many years (and still is used to some extent) for very small isolated power (2 or 3 hp.) in buildings, on farms, etc. Thought to be of very minor importance.



INTERNAL-COMBUSTION ENGINE (OTTO CYCLE)—Basically similar to the hot-air engine, the internal-combustion engine (Otto cycle) heats its gas by internal combustion. Piston draws in explosive

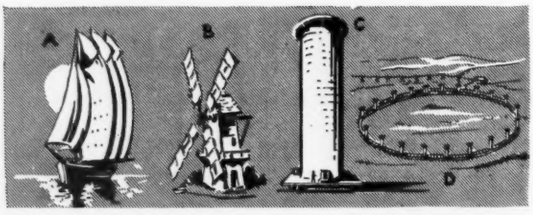
mixture of air and gas (or liquid vapor), compresses, ignites by electric spark, lets mixture expand while doing work, exhausts spent gases. This is the "4-stroke cycle" of operation, most commonly used. Otto cycle is comparatively efficient, although less so than the diesel cycle, which eliminates all possibility of preignition and thus makes higher compression possible.



DIESEL ENGINE—Fundamentally the diesel is a hot-air engine heated by an internal flame. Pure air is drawn in on suction stroke, compressed to around 500 lb., bringing it well above ignition point of oil. Heavy oil, or other liquid fuel, is sprayed in during first part of working stroke, burning and heating the air and combustion products. Then follow expansion, release and exhaust. The essential diesel characteristic is compression of air alone to a high pressure and a resulting temperature high enough to ignite the fuel.

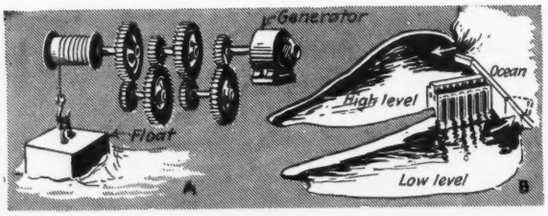
The diesel is today the most efficient of all commercial prime movers but nearly equalled, in this respect, by the mercury-steam cycle.

UNUSUAL POWER PLANTS



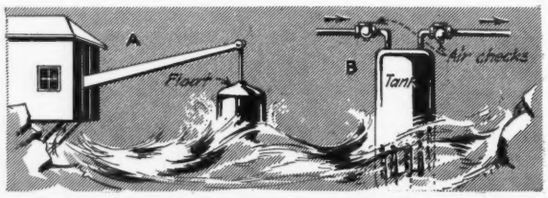
POWER FROM WIND—Animal power (including human) came first. Second and third, presumably, were water power and wind power. From antiquity until now ships (A) have absorbed impressive amounts of power from the wind. For hundreds of years, windmills (B) have pumped water and ground grain. Large-scale wind-power development is still being agitated and large increases have been made in the efficiency of wind plants with the aid of modern aerodynamic theory. One trend has been toward airplane-propeller-type blades.

Quite different is the Madaras "Flettner-rotor" power plant. In this rotating towers (C), utilizing the so-called "Magnus effect," act as efficient sails to propel the supporting trucks around a circular track (D) of large diameter. Electricity is to be produced by generators geared to the truck wheels. A single full-sized rotor (90 ft. high) has been constructed and operated experimentally.



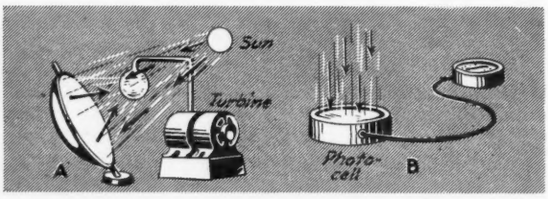
POWER FROM TIDES—The enormous forces produced by the tides, and the simple mechanism needed, have led to popular delusions regarding tide power, particularly from floats. Consider (A) a float displacing 1,000,000 cu.ft. Geared up, its motion would operate a generator producing (theoretically) an average output of 20 kw. with a 10-ft. tide. With 50 per cent efficiency, complete utilization, $5,000,000 first cost and 10 per cent fixed charges its output would cost $5.70 per kw.-hr. for fixed charges.

Much more promising are tide-power schemes involving the use of natural reservoirs. The ideal situation is provided by adjacent high-level and low-level reservoirs in which the water levels are maintained by one-way check gates to the ocean, as indicated in the sketch (B). Several small tide-power plants are operating commercially in various parts of the world. A million-kilowatt installation on the Severn Estuary, England, has been urged after an exhaustive study.



WAVE POWER—Contrary to popular impression, power by direct action of waves on mechanical devices (A) is less visionary than tidal power from similar devices. The difference lies in the far greater rapidity of the wave motion. Thus a float rising and falling 6 ft. every 10 seconds could generate 4,500 times as much power as the same float on a 6-ft. tide since the tidal cycle is 12½ hours.

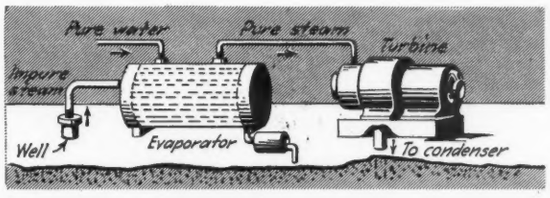
Stationary tanks (B) may be used for production of low-pressure compressed air by wave action. So far all wave-power schemes have been commercial failures.



POWER FROM SUN'S HEAT—At present the only important commercial production of power from the sun's radiation is through the indirect action of the sun in producing fuel, waterfalls and wind. In trop-

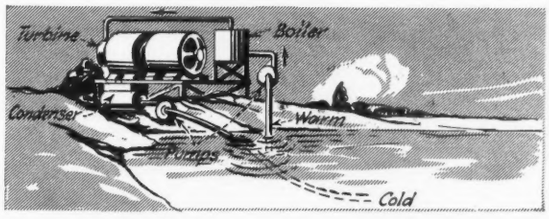
ical regions, and also in the United States, have been constructed occasional small plants (A) using mirrors to direct the sun's rays on boilers driving small engines or turbines. Some of these are still in operation. For normal power generation, even in cloudless tropical regions, such plants are generally considered commercially impracticable, although their possibilities have not been fully explored with modern apparatus. Assuming a radiation intensity of one kilowatt per square yard, 1,000 sq. yards of metal mirror area applied to a 20 per cent efficient plant could generate 200 kw.

Small photo-electric cells (B) of about 2-in. diameter, now on the market, generate sufficient power from sunlight to operate micro-voltmeters and delicate relays. Yet actual efficiencies are negligible and present experimenters in this field are in the main skeptical regarding the future possibility of generating electricity commercially in this manner except in the minute quantities required for operation of relays and delicate instruments.



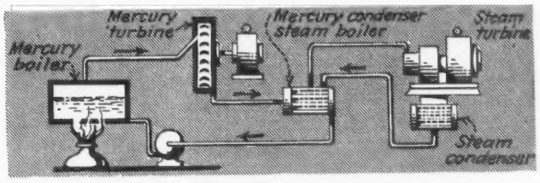
Power From Earth's Heat—Power (about 7500 kw.) has for some years been commercially generated from the earth's heat at Lardarello, Italy, where steam wells have been drilled in a natural-steam district. These wells supply tainted steam to heat exchangers, which in turn deliver clean steam to the turbines. The hookup is sketched above. Power from natural steam is also generated at the Geysers, Calif.

Just a few years ago Sir Charles Parsons proposed that a twelve-mile deep hole be sunk in the earth to generate steam from the earth's heat.



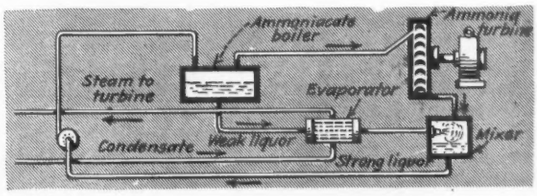
Ocean-Heat Plants—Two plans for generating power from ocean heat have been seriously proposed in recent years, one for the tropics and one for polar regions. Georges Claude, inventor of the Neon lamp, spent more than a million dollars in Cuba demonstrating his scheme for producing power from the large difference of temperature between deep water and surface water in tropical seas. His experimental plant (shown schematically above), developed a little power, but less than enough to operate its own auxiliaries.

Even ice water contains heat. This heat can be used to produce power if a still lower temperature is available in the same place. The French engineer Barjot thus proposed to utilize the temperature difference between under-ice water (about 32 deg. F.) in Polar seas and the sub-zero air above the ice.

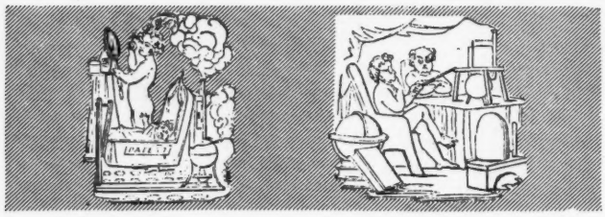


Mercury-Steam Cycles—Undoubtedly the average engineer would still view the mercury-steam power-generating cycle as purely visionary if he did not face several plants that are in successful operation after some years of experimental work costing some millions of dollars. The general scheme of operation is shown in the sketch. Mercury-vapor, produced by the fuel-fired mercury boiler, drives mercury turbine and exhausts to mercury condenser, there producing steam for operation of condensing steam turbine, or non-condensing turbine exhausting to process.

The best installations of this type give today a kilowatt-hour for about 9,500 B.t.u. net, whereas the best commercial condensing steam plants require about 12,200 B.t.u. In spite of the mechanical and thermal achievements of the mercury plant it must face the future competition of improved steam cycles and also the presumably lower investment cost of the ordinary steam cycles. In addition it may have to compete with binary-vapor cycles utilizing other fluids than mercury.

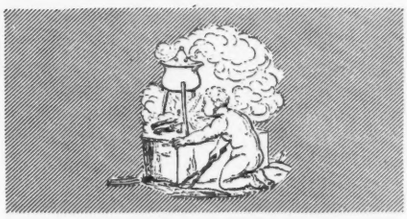


Steam-Ammonia Compound Cycle—Efficiencies approaching those obtainable with the mercury-steam cycle have been predicted for plants combining the steam cycle with a superimposed cycle in which certain ammonia salts are decomposed by heat in a boiler. The ammonia gas so formed drives a turbine. Weak compound (that is, with most of the ammonia boiled off), is drawn off from the boiler and passed through an evaporator, where its heat produces steam to operate a condensing turbine. It then recombines with the ammonia gas, exhausted from the ammonia turbine, and returns as a strong ammonia compound to the boiler. Thus the power plant becomes a sort of chemical factory. Many other binary-vapor combinations have been proposed and tried, but only the mercury-steam cycle is in practical operation at the present time.



"In Today Already Walks Tomorrow"
—Coleridge

First printed more than a century ago in Stuart's "Anecdotes of Steam Engines," the quaint vignettes on this and succeeding pages depict "power's future" and prove that the humor of a mechanical age was born before 1829



NO MAN may say for sure what the future will be, but this Fiftieth Anniversary Number would not be complete without some attempt to draw back the veil which hides the future course of power developments. Mr. Orrok has accepted this interesting but dangerous assignment. He writes from a unique experience in the field of power engineering, yet all readers will not agree with all of his conclusions—nor would he expect so much. His comments will surely stimulate the creative imagination of power engineers—Editor.

TOMORROW

By GEO. A. ORROK
Orrok, Myers & Shoudy, Consulting Engineers

IN this particular article we are not so much interested in the lessons of the past as we are in the prospects for the future. I shall therefore attempt to indicate some of these anticipations, with the reasoning upon which they are based, and may even venture a few speculations of a more nebulous nature, touching upon possible developments which throw no more than a faint shadow upon the engineering practice of today.

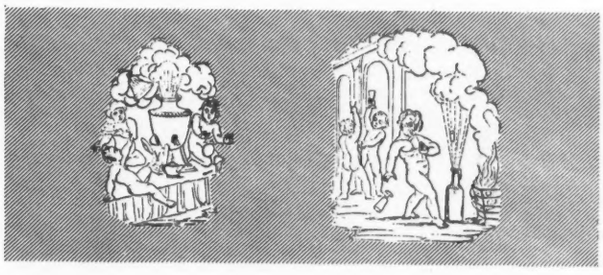
Our power-making activities may be classed under a number of heads, most of which go back to a time long before this magazine commenced its publication. Of the many power ideas considered and tried in the past, some will surely rise again for renewed consideration in the light of greater scientific knowledge.

Consider, for example, the primary battery. Engineers and scientists of imagination have always been intrigued by the thought of the direct production of power or electricity by the combustion of certain inexpensive substances in such batteries. At the very time of *Power's* founding, inventors and research engineers were working on the problem of the direct production of electricity from coal in some kind of a primary battery. One of these, named Jencks, brought out a caustic cell with coal as the consumable electrode. His invention was heralded as the dawn of a new era which would abolish the wasteful burning of fuel under boilers to raise steam which then could be used in engines, in turn driving generators by belts. Unfortunately, the Jencks cell polarized very quickly and no modification or addition was found that would prevent this polarization.

Since that time many inventors and research scientists have been working on this primary battery problem, which today is not much further advanced. Yet who can say that the unfolding physics and chemistry of the future will not revive the primary battery as a major power source?

We get down more to the earth of present-day engineering when we consider the second source of power which has attracted the attention of inventors, engineers, and scientists. I refer to the fluid-pressure engine, exemplified by the windmill and waterwheel. Here has been real progress. Single units of 150,000 hp. are planned for the Grand Coulee project. Water-turbine efficiencies of 95 per cent have already been attained. Clearly there is little room for improving efficiency.

The Geological Survey has estimated that the potential water power in the United States, utilizing every source that could conceivably be developed for less than $500 per kilowatt may represent a total of 32,000,000 kw. available 50 per cent of the time, or an output of roughly 150 billion kw.-hr. per year. This is the maximum output of power from water which we have any right to expect in the United States. The cost of developing remaining sites will in general be progressively higher. It will probably be many years before our present installation of



10,000,000 kw. of hydraulic power will be notably increased.

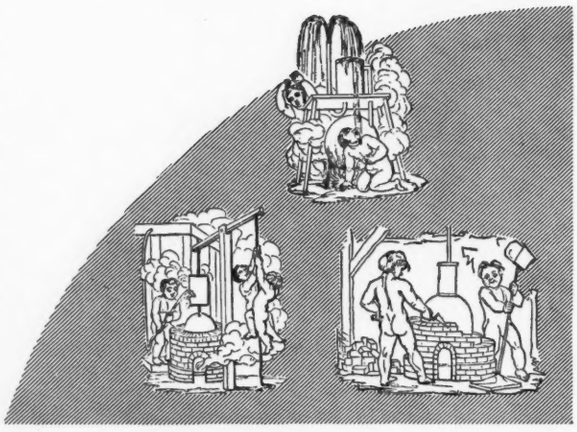
Some engineers feel that wind power has an important future; I incline to disagree. Wind power is most uncertain. It is usually considered that the velocity of the wind must exceed 8 miles per hour before the friction of the apparatus can be sufficiently exceeded to pay for the working. Yet when the wind velocity exceeds 20 to 24 miles per hour the danger of wrecking the apparatus places another limitation on its operation.

Thus the average availability of wind power is cut down to very small dimensions indeed, perhaps less than 2,000 hours per year average for the United States as a whole, and even less in certain regions. Those islands of the West Indies and elsewhere where trade winds blow almost continuously provide little market for power. Wind-power plants themselves, as exemplified by the Savenius mill and the Flettner-rotor wind power plant, have been enormously improved in efficiency, yet all labor under the disadvantage of low average availability. Without doubt the windmill, in whatever form, is not the power plant of the future.

OF THE familiar types of prime movers there remains only the heat engine for our examination, and here we may properly divide our subject under the three usual heads of air engines, explosion engines, and the steam engine and turbine. All are characterized by the temperature range of the working fluid. Their maximum efficiency may not exceed that of the well-known Carnot cycle.

The air engine, in which ordinary atmospheric air is expanded by external heat, may quickly be dismissed because of its inordinate bulk per unit of capacity. The same in principle, internal-combustion engines present a very different type of picture. They are enormously important today and may be more so in the future. Practically all automotive engines, and many stationary engines in the gas fields, operate on the otto cycle wherein a compressed mixture of air with gas or vapor is ignited by a spark.

Big brother to the otto cycle is the more efficient diesel cycle in which air without fuel is compressed to above the ignition temperature before the fuel is sprayed in at the beginning of the working stroke. Including automotive equipment, more than two-thirds of the installed capacity furnished by present-day prime movers comes from the internal combustion-engine in its various forms. Of these forms the diesel engine apparently holds greatest promise for the stationary power plant.

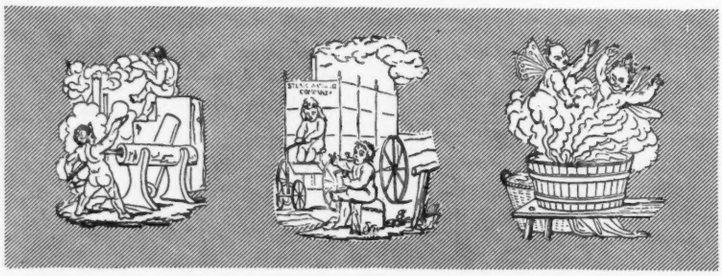


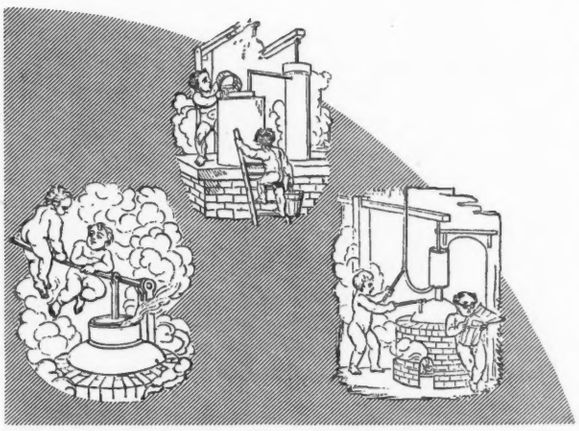
I hesitate to predict the future of the internal combustion engine. Dr. Ricardo, in the sixth Thomas Lowe Gray lecture before the Institution of Mechanical Engineers in London last December, made a bold plea for the use of the light-weight high-speed diesel engine for marine propulsion. He proposed an engine running at about 1,700-ft. piston speed in 100-h.p. units, installing 75 of them on one ordinary electrically driven ship of possibly 15,000 tons. In this lecture he states the pros and cons of such an installation and ends up with an arraignment of the modern 5,000-hp. diesel.

Dr. Ricardo's thinking has been along the same lines as that of the manufacturers of automobiles and motor boats, who aim at an entirely automatic four-, six-, or eight-cylinder diesel set which will be self-contained and capable of running many thousand hours without overhaul. I confess I cannot enthuse over an installation of the magnitude suggested by Dr. Ricardo, and would rather take my chance as an engineer on a double set of six-cylinder engines running at not over 900-ft. piston speed.

I do not think it likely that diesel engines of the future will run to very much larger sizes than those that have already been built. Moreover, it is generally agreed that diesel engine efficiencies cannot rise much above those obtained by Dr. Diesel in his best engine and that size has little influence on efficiency. On the other hand, there is definite possibility that lower cost, based on quantity production, may improve the position of the diesel.

Despite the imposing aggregate capacity of internal combustion engines, the steam engine and the steam turbine are today the main method of power generation in stationary plants. It is probable that





between 60 and 70 per cent of the horsepower hours used in this country are generated in steam engines or turbines and that two-thirds of this power is generated by the use of solid fuel burned under boilers.

In my paper before the American Society of Mechanical Engineers in 1930, I ventured some predictions regarding the boiler room of the future and predicted that the desire for a clean atmosphere, and freedom from dust and smoke, would eventually compel the burning of fuel in a gaseous form in all of the centers of population. I predicted a boiler of small physical dimensions with high speeds of circulation of both the gases and the water and steam. I predicted a cellular construction or its equivalent, which would allow reasonably small units to be built up into larger units under one master control and thus solve the problem of size.

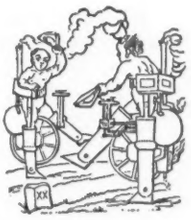
Since then an actual trend in this direction has been evidenced by the new pressure-combustion, forced-circulation boiler which burns gas or oil and whose velocity of circulation exceeds that of sound. The unit is self-contained, occupies an exceedingly small space and can be controlled from a distance. Six installations are in use, with others to follow. Efficiencies obtained are of the highest order, comparable with anything so far achieved by standard designs.

We have other types of cellular construction, where the boiler consists of a single tube coiled back on itself and so arranged as to present the proper surface for heating, evaporating and superheating. There are other boilers on the market which promise to lend themselves to some such arrangements as those predicted in the 1930 paper.

The reciprocating engine has apparently already reached its economical limit of size. We have steam engines with four cylinders which have developed an indicated horsepower around 25,000. For such large capacities the trend has long been toward turbines which concentrate the power within much smaller dimensions. Steam turbines developing 225,000 hp. on a single shaft are today in existence and are not large machines as we used to view the steam engine. Further concentration of power within a given volume may well result from the adoption of the extremely compact radial flow machine with double and opposite rotation of two nested rotors driving two generators.

My impression of the steam power plant of the future is a self-contained hermetically sealed gas-fired boiler placed alongside or next to a turbine with its condenser underneath. All this to be contained in one room, well lighted and ventilated, where it can be operated by one man through distant controls. Even today we have anticipations of such power plants.

Such plants would be built to run from 6,000 to 8,000 hours per year without stopping or overhauling and would be capable of being started or stopped by one man with a hand at the switchboard. And, as the various parts of this combination are nearly fool-proof today, the combination itself should be even more fool-proof than the separate parts.

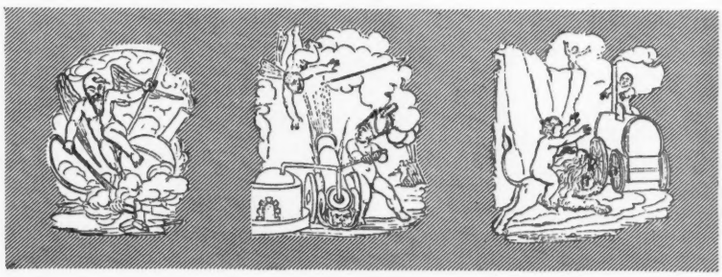


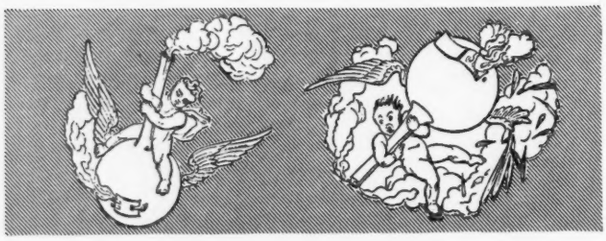
FOR the future steam plant I expect to see a less costly structure, absorbing perhaps 20 per cent of total plant cost, as against the present 30 or 40 per cent. This in a way will return to earlier practice.

Cheaper switch gear is another probability. It seems quite likely that the vacuum tube may in the near future replace the complicated oil circuit breaker. The use of this type of apparatus may easily double or triple the capacity of all three-phase transmission lines and give much greater stability at very slight cost. These proposals have been put forward by C. W. Stone of the General Electric Company at a meeting of the American Society of Civil Engineers last year.

It would appear that three-phase generation, direct-current transmission at high tension, and the substitution of vacuum tubes for our present complicated and high-cost switching arrangements, will cheapen substation and transmission costs in a marked degree. These tubes can be water cooled and the equivalent of 2,000-kw. capacity can be carried in the arms of one man without seriously overloading him.

No investigation of this kind would be complete without an examination of the various binary vapor





power systems which have been invented and used in power generating systems. They find their application in the increasing of the temperature range through which the working fluid is carried and have for their object the increasing of the efficiency according to the Carnot cycle. The types and kinds of these binary vapor engines are many and their history long. Combinations tried include ammonia-steam, ether-steam, chloroform-steam, mercury-steam, diphenoloxide-steam, aluminum-bromide-steam and others. They go back to at least a full century. Every one was highly efficient from a thermal standpoint, but all were eventually abandoned.

Our mercury-vapor plants installed in this country at Hartford, Schenectady, and Kearny all report very good efficiencies, but no figures are as yet available on the commercial economy. Perhaps these binary-vapor installations will have a rather different experience from all of the others which have preceded them. Nevertheless it is my opinion that this form of apparatus will not take its place as a primary power plant of the future.

IN RECENT years the technical press has commented on the proposals of Georges Claude of Paris, who makes power on the temperature difference in tropical waters between the depths of the ocean and its surface, and of Dr. H. Barjot who would locate his power plants in the Arctic regions and use a temperature difference between water under the ice at 34 deg. and a brine freezing mixture. It is difficult to see how propositions of this kind can make any large amount of power for the use of our centers of population, which are located thousands of miles from either source.

Other possibilities, equally fantastic at first glance, may prove more practicable. The discovery and use of catalysers for example, have introduced a new factor into chemical engineering which may have a very important influence on the making of power. These catalysers are now used in a great variety of chemical processes where new combinations are created merely by the passing of their component parts through a chamber containing the catalyzing medium. Such catalysers have also been used to induce a change of physical state and it strikes me that this fact may some day enable us to do away with certain parts of our power making machinery, thereby simplifying the processes and cheapening the result.

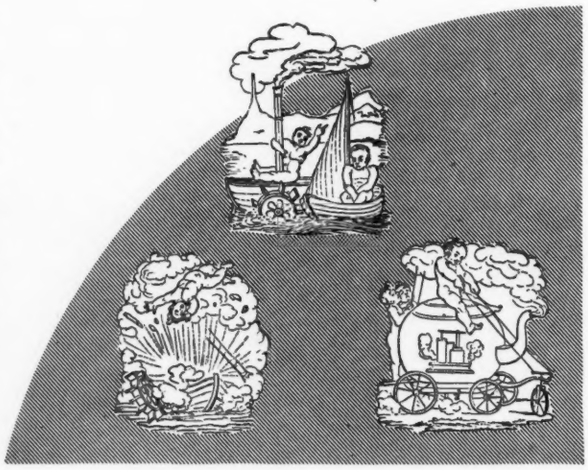
Other mediums may be used in heat engines to replace steam with its excessively high latent heat. We can imagine substances of high molecular weight and low latent heat, which can be gassified under pressure at a small expenditure of heat, expanded to produce power and liquefied by a catalyser, with heat interchangers to pass the latent heat on to the incoming side of the equation.

In many cases a temperature range nearly as large as that of steam could be secured with a working fluid much more dense than either steam or mercury vapor and lending itself very well for power generation in a turbine. In such cases the boiler and condenser would be simply a heat interchanger of comparatively small dimensions and the whole apparatus would offer advantages in size and velocity for use in the production of power.

There have been predictions that high-frequency rays or brush discharges might be used to produce similar results. New substances of high molecular weight and low latent heat are being added to our knowledge from time to time. We also have similar anticipations in the reversal of the absorption cycle in refrigeration to generate power instead of using it. Particularly promising is the use of certain amino-compounds which readily part with a portion of their ammonia content, absorbing it again at the low point of the cycle after the work of expansion has been completed.

While we are on these highly speculative subjects we should not overlook radio activity, and those recent achievements in which atoms have been broken up by bombardment with alpha particles. The enormous internal energy of the atom is an established scientific fact. It has been proved that some of this energy can be released by bombardment.

Some scientists have claimed that the molecular energy of the type considered could not be transformed into power, but even here the miracle would be not too great. Who shall say what changes in the methods of power development may follow from these fundamental discoveries of our physicists.



OIL & GAS ENGINES

What of Their Future?

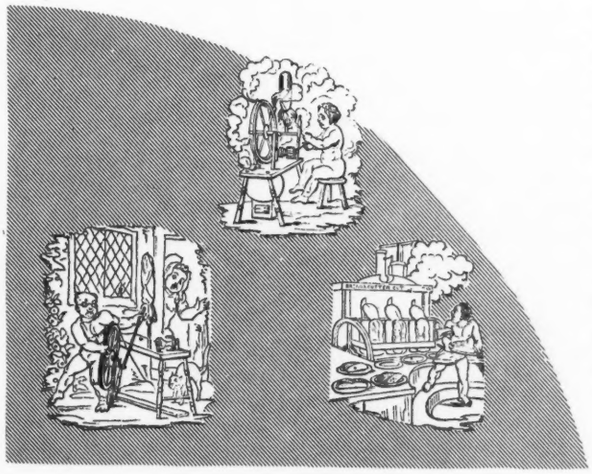
By E. J. TANGERMAN

Assistant Editor

MR. ORROK has covered all methods of power generation, but with the emphasis on steam. It seems only fitting, therefore, that separate consideration be given to oil and gas engines. I have sought the views of engineers with intimate knowledge of diesel problems. Their views are here assembled in one picture. But their opinions vary in so many details that it would manifestly be unfair to hold them individually responsible for any of these statements. Here, then, is one composite picture of the future:

Steam traditions still befuddle diesel thinking. Forgetting process plants for the moment, steam plants increase rapidly in efficiency with increases in plant size, and unit investment falls off. Thus large steam plants are more economical. But men who apply the same conclusions to diesels go haywire. The small diesel is almost as efficient as the large and costs but little more, if any, per unit of capacity. The plant composed of several small diesels may, and should, be more efficient than the large because of its inherent flexibility. Thus the diesel may be the logical answer for small isolated loads. It seems unlikely that the large steam plant will face much competition from the the large diesel plant; the small condensing steam station will.

The diesel and the steam engine face the same labor problem in small plants. A 25-kw. diesel plant may be practically as efficient as a 2,500-kw., but if taken care of by a full-time attendant, its labor cost will be almost prohibitive. Two ways out are part-time attendance and the automatic plant. In either the operator should be simply a "chauffeur." Routine maintenance and repair should be handled by the garageman, a specialist. Central servicing organizations might be set up, similar to elevator-maintenance companies, or better still, companies which simply sell power and rent engine space.



High cost has been a diesel bugaboo, largely because all large units, and most small ones, have been custom-built. Probably diesel manufacturers will some day select a few standard sizes of a given type and will sell engines on that basis only—if the purchaser wants red paint he pays extra.

Too much time and money have been spent trying to improve the efficiency of an engine already far higher in this respect than any other prime mover. What we need now is reliability and low unit cost. Conceive for the moment that Henry Ford (he probably won't, but conceivably might) decides to equip all his cars with diesels. Suppose he redesigns for longer service life. His present V-8 engine will deliver about 60 hp. continuously and sells for about $300—$5 a horsepower. Quadruple that and you still have only $20, less than half the cost of the present diesel.

WITH this arrangement, the larger the plant, the more engines. Ricardo proposed motorships driven by batteries of small diesels; Lucke long before proposed it for submarines. Why not also for stationary plants? Mass production, lower cost, plant flexibility, greater reliability, greater economy, all are possible.

There is always the spectre of higher fuel cost, however. If the diesel becomes common, its fuel will be in greater demand and will cost more. This might definitely favor coal—even Herr Diesel's original idea, the powdered-coal diesel. As a large unit, the diesel's future is not too sure, except in specific cases. Abroad, yes, for there the situation is very different—*the value of fuel in terms of human labor is ten times as great as it is in the United States.*

Design trends are apparently toward higher rotative speeds, greater compactness and higher mean cylinder pressures, all resulting from engineering improvements. Better design and workmanship and better auxiliaries are reducing labor and maintenance costs, increasing reliability. Solid injection will probably succeed air injection in most cases. Some authorities doom the four-cycle engine, because the two-cycle has no valves, has smaller cylinders and floor-space requirements, lower first cost, is lighter, has less maintenance. Others think not, claiming two-cycle units present greater cooling problems, are harder to lubricate, have lower m.e.p. and require scavenging equipment. Efficiencies of the two types are theoretically the same—the two-cycle needs still some real talent in design. Large power require-

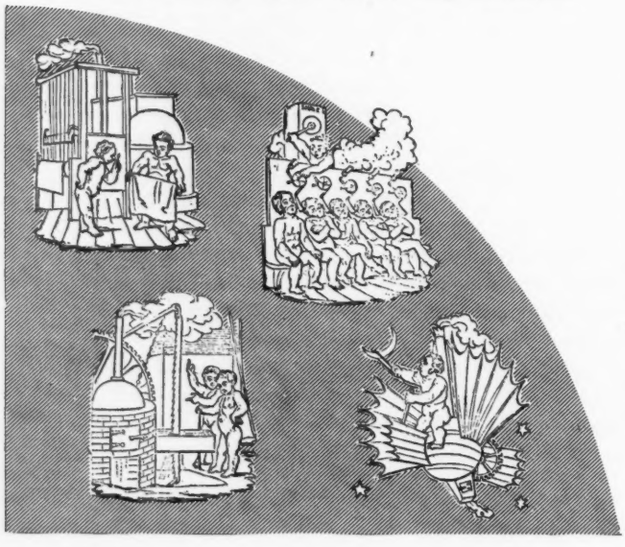
ments may justify double-acting engines, although this seems unnecessary in the sizes made in quantity.

These remarks have all related to the stationary diesel. Many authorities see its greatest future in motive power—for long-haul truck and bus service in light-weight, high-speed trains, wherever its efficiency has a chance to have its effect. In marine work it means low-cost operation and no fire hazard, in airplanes dependability and reduced fuel cost, longer cruising range. But for the automobile, authorities are not sure. Possibly a low-compression, spark-ignition oil engine, but not the diesel. Car owners pay today for getaway, surging speed, easy starting, not engine economy. In what they pay for, diesels are today not as good as gasoline engines.

So much for the diesel. Learned men a short ten or twenty years ago sounded the knell of the gas engine. The diesel was better unless waste gas was available, as in process plants and steel mills. But now, as natural gas lines spread over the country in a great network, the gas engine looms again as an economical prime mover. These lines carry natural gas now, but could just as well carry high-B.t.u. gas produced at mine mouths. Refineries are also using gas engines increasingly to utilize still gas.

IN ANY case, we shall need more power. It is logical that internal-combustion engines will supply much of it, particularly as design and reliability are bettered, cost is reduced, and we as a nation begin to understand these engines.

The authorities who have generously consented to contribute ideas include: Charles E. Lucke, Geo. A. Orrok, B. B. Williams, R. H. Morse, E. T. Fishwick, Max Rotter, R. P. Lay, J. H. Gallaway, P. H. Schweitzer. We must here reiterate that these men each gave us his opinions; we have made of them a continuing story; thus it is unfair to hold any of them individually responsible for any statement.



POWER FROM THE ATOM?

By Dr. ORESTES H. CALDWELL

Editor "Electronics"
President New York Electrical Society
Former Federal Radio Commissioner

THINK back only twenty years and you will recall that the play of electrons in vacuum tubes was known only to a few scientists. The electron itself was an entity wholly outside of the understanding or conception of ordinary people. The antics of these tiny particles in evacuated glass bottles would have seemed an absurd subject on which to pin hopes of future commercial development.

Yet out of those electronic capers—from that dance of infinitesimals—came all the present-day miracles of radio, broadcasting, talking motion-pictures, round-the-world telephony, remote control of ships, radio fevers, the electronic knife, location of underground treasure, the electric eye, and so on.

Today these miracles are common-place and a part of every-day life. And today the electron, and its behavior in vacuum tubes, is familiar to every schoolboy. Just because we cannot see or handle these electrons at first-hand like so many peas or BB shot does not mean that we do not have a clear conception of what an electron is and how it acts. We are dealing with entities perhaps as much smaller than a grain of sand as the grain of sand is smaller than the earth. Such dimensions stagger the imagination. Yet today we have no doubt of the electrons' ability to "deliver the goods" when we tune in on our favorite radio program or drop into the neighborhood movie.

Now the same group of scientists who trained the electron in its present useful performances are moving forward into new fields of electronic exploration. And they find that seemingly the electrons in ordinary matter all around us are the repositories of enormous quantities of energy. Each atom is apparently made up of spinning "solar-systems" of electrons. Each atom of hydrogen, iron, gold or lead, is a revolving group of electrons, the number of electrons in each atom being proportional to the weight of the material. Thus each atom is a tiny fly-wheel rotating at terrific speed. The velocities at which these infinitesimal rotors move also challenge our imaginations. For the electrons that make up the average atom revolve around their central nuclei several thousand million million times per second. The speeds at which the electrons travel in their orbits reach hundreds of miles per second—speeds far faster than the planets in their orbits.

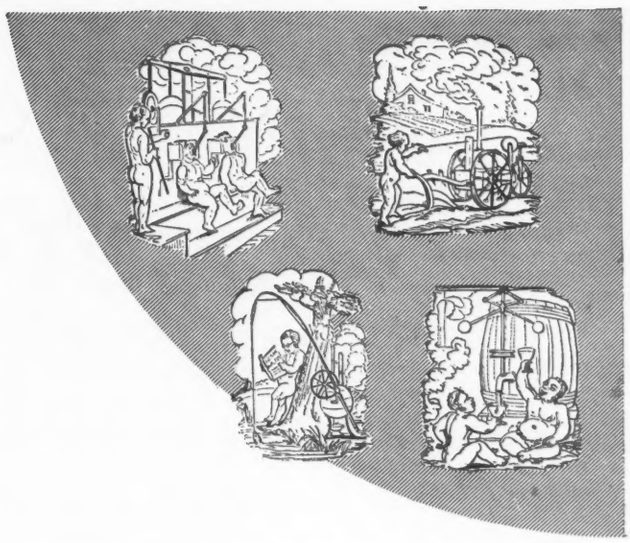
Revolving at these tremendous speeds, it would seem that once in a while some of these electrons would get thrown off, like sparks from a pin-wheel. And this is exactly what happens in some of the larger atoms, the heavier collections of electrons where the electron planets go spinning around in less stable formation. These are the so-called "radio-active" atoms, like radium, uranium, etc. And the electron groups thrown off of those spinning atoms strike with tremendous force, if they hit anything in their neighborhood. Even the relatively insignificant fragments loosened from the atomic flywheel reveal that they contain enormous energy. What then must be the rotational energy of the main parts of the flywheels which still go on spinning!

This is the great problem that is challenging the efforts of science in 1934. This is the query which has led to the construction of great electrostatic machines, capable of delivering 10,000,000 volts, and vast electromagnets producing magnetic-field intensities never before reached, all in the effort to bring more and more powerful battering rams into play in the attack on the atom, and the age-old problem of converting one kind of atom into another. For as the atoms are "transmuted" from one arrangement of electrons to another, it is evident that pulses of energy will be given out, and these pulses may be the power source of the future.

ALREADY in the laboratories, the lighter atoms have been transmuted. With the few millions of volts available, electronic projectiles have been driven into the hearts of atoms made up of fewer electrons, and the investigators have been rewarded by finding traces of wholly new—and lighter—elements left behind. Undoubtedly these transmutations gave off some energy, although with the apparatus we have today, and with our present crude methods of bombardment, the energy input necessary to bring about the transmutation or atomic explosion was far, far greater than the energy derived. But that does not mean that continued investigation may not disclose the method by which some slight "firing" energy may be sufficient to kindle the electronic furnace to produce energy outputs of untold intensity and temperatures.

And for evidence that complete energy conversion of matter is possible in nature—that is, that the whole 100 per cent of the electronic flywheel can be whiffed away into energy—we have only to look up at the sun overhead, and reflect for a moment on his tremendous output of heat energy.

Each square inch of his surface is continuously radiating 50 hp. or about 37,000 watts. His mass, two thousand million million million million tons,



radiates about 500 sextillion horsepower of energy, a quantity beyond comprehension. Yet during all the years of accurate observation of the sun's diameter, no detectible reduction of his size has been discovered. A power plant to produce any such output of energy would consume coal at the rate of many thousands of millions of millions of tons per second.

Evidently the source of the sun's energy is something different from ordinary chemical combustion as we know it. It certainly is a process by means of which prodigious amounts of energy are extracted from matter continuously, yet without detectibly reducing the mass or dimensions of the material source, except as measured by delicate methods over long periods of time.

In fact calculations show that the present mass of the sun will go on producing its present rate of output of energy for 15,000,000,000,000 years.

All evidence therefore points to the fact that the sun's energy is inter-atomic in character, that in the tremendously hot interior of the sun, matter is being actually distilled away into energy, right before our very eyes.

The sun does it. Why cannot the processes of the solar furnace be reproduced in our own laboratories. The tremendous energy rewards to be obtained by this process are shown by the figures above, revealing that in a single pound of coal there are untold millions of kilowatt-hours of inter-atomic energy waiting to be unlocked by the proper "key" or kindling.

Great laboratories all over the world are now concentrating on this problem of inter-atomic energy, and its twin-query, the transmutation of elements upon a scale of industrial significance. At many points along the line, doors leading to the inner mysteries now seem just ajar, and already a little light gleams through each crack thus opened. New facilities, new voltages, new powers, new machines are all aimed at the task.

The problem of inter-atomic energy seems about in the position which heavier-than-air flying held prior to the present century. Conceivable and possible, yes—but not yet achieved.

THE ENGINEER OF TOMORROW

By PHILIP W. SWAIN
Editor of Power

• PREDICTION is definitely risky, except where the momentum of projected events is so great, and the target so large and close, that a miss is clearly unlikely. Thus the swiftly pitched ball halfway to the side of a barn is a safe bet for a hit, but woe betide the prophet who announces now the results of congressional elections in the year 2034. Guessing the future of the engineer seems to be a middling risk, considerably safer than the congressional prophecy, more risky than the barn-side bet.

As a citizen, the future engineer must stand or fall with the civilization of his day. If that civilization goes to pot, as some predict, the engineer goes with it. The idea of supermen handling super machines in a superlative age all hangs on the actuality of such an age.

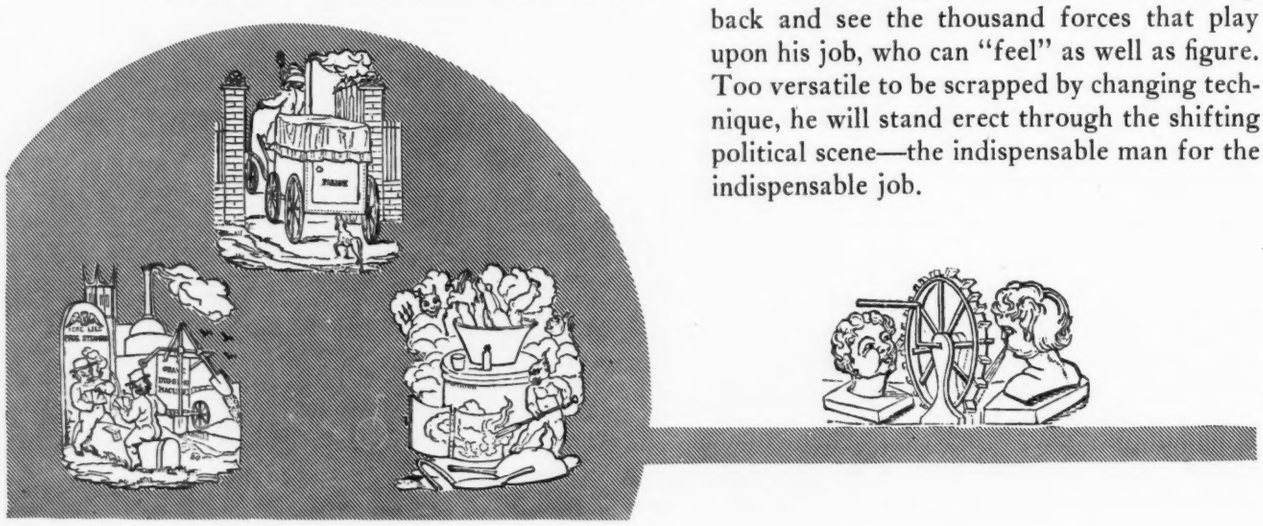
Even I, with my native optimism, can't quite vision this confused world blossoming into Utopia in the next ten or fifty years. But neither do I picture my great-grandchildren wandering with vacant stare through the piled-up rust of today's civilization. My guess is that we shall see innumerable and profound changes in social and political organization, but that man will not pitch out of the window the machinery which feeds and clothes him.

We shall have machines, and machines will always require power and power engineers. If technique advances, as in all reason it will, these power engineers must be bigger men and better trained than today. Here then is sure work, come what will, for men of the right substance. Power engineering is and will be an absolutely necessary function. If social changes are in the cards, some of the parasitical jobs may be eliminated; security lies in being indispensable, in being a leader in a line of work that cannot conceivably be abolished under any political system.

No one can predict the detailed technique of future engineering, but its broad outline is already clear enough: more difficult and varied technical problems. More need for understanding of men, money and human relations. Increasing complexity all along the line.

More science, yes, but above all, broader grasp, better intuitions—more skill in quick and right decision. The best advice to the young engineer is to forget the old saw about learning one thing well and sticking to it. Rather try to grasp the fundamentals of a dozen fields. Broaden to the limit—but basically, not thinly on the top.

Even more than today, the great engineer of the future will be the man who can step back and see the thousand forces that play upon his job, who can "feel" as well as figure. Too versatile to be scrapped by changing technique, he will stand erect through the shifting political scene—the indispensable man for the indispensable job.



THE NAME COCHRANE REPRESENTS

50 Years

of steady and continuous progress in the CONDITIONING of BOILER FEED WATER and the UTILIZATION of STEAM

THE Cochrane Corporation is the continuation and successor of the Harrison Safety Boiler Works, organized in 1863 to manufacture boilers that were safe against explosion. Improving the equipment of steam plants, including the purification of water for boilers, has been the special occupation of our engineering staff from that day to this, as shown by the list of PRODUCTS and dates on the reverse page.

The Cochrane technical staff and research laboratories are constantly engaged in the solution of problems related to the conditioning of water for boiler feed and industrial purposes, to the purification and utilization of steam, to the metering of steam, air and water, to the prevention of scale, embrittlement, priming and corrosion, and to the conservation of heat and water in steam plants.

If you have problems of the nature described, we will be glad to confer with you or to send appropriate literature.

COCHRANE CORPORATION

PHILADELPHIA, PA.

See next page—

COCHRANE PRODUCTS

In 1883 **OPEN-FEED WATER HEATERS** of cast iron plate construction, and of which many millions of horsepower have been installed in American steam plants, were first built, and shortly thereafter STEAM and OIL SEPARATORS were placed on the market.

In 1892 **HEATERS and RECEIVERS,** for use in connection with exhaust steam heating systems, were brought out.

In 1901 **HOT PROCESS SOFTENERS** were introduced.

In 1909 **MULTIPORT BACK PRESSURE VALVES** were first marketed, in which year also was begun the development of the DEAERATING HEATER.

In 1910 **STEAM-STACK and CUT-OUT VALVE HEATERS** were first built.

In 1915 **CHEMICAL FLOW PROPORTIONERS** were first used for supplying softening reagents in constant ratio to the flow of raw water.

In 1919 **MULTIPORT DRAINERS** were introduced for discharging large volumes of condensate under low pressure.

In 1920 **JET HEATERS** originated.

In 1922 **MECHANICAL FLOW METERS** were first marketed, in which year also ZEOLITE SOFTENERS were introduced.

In 1924 **CONICAL FILTERS,** requiring no strainers or manifolds, were first sold, although prior to and since then many filters of the strainer type have been supplied.

In 1926 **ONE-PIECE TANDEM STEEL BOILER BLOW-OFF VALVES** for the highest pressures were first sold, and the same valves have been in continuous service ever since.

In 1927 **STEAM PURIFIERS,** as also the PILOT-ACTUATED DISCHARGERS used therewith, began their notably successful service.

In 1928 **CONTINUOUS BOILER BLOW-DOWN SYSTEMS** and the ACID FEED for correcting excessive alkalinity, were introduced.

In 1930 **PILOT-ACTUATED REGULATING VALVES** were brought out.

In 1932 **MARINE DEAERATING HEATERS,** designed to function in spite of pitching and rolling, were first installed on shipboard.

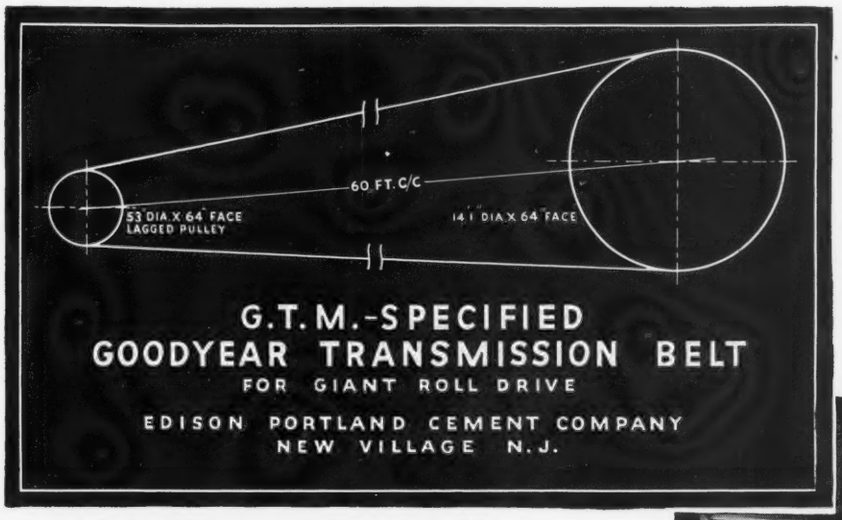
In 1934 **ELECTRIC FLOW METERS,** utilizing the precise null or zero-balance method, make their bow.

Ask for Bulletins describing those lines in which you are interested.

COCHRANE CORPORATION

17th & Clearfield Streets, Philadelphia, Pa.

NOT A MINUTE'S TROUBLE IN 12 YEARS



650 to 850 horsepower loads at 325 R.P.M.

GOODYEAR TRANSMISSION BELT NEVER FALTERS ON GIANT ROCK-CRUSHER DRIVE

Called "remarkable" after 4 years' service in '26, it is still going strong today

A GM JOB

HERE is the saga of a belt that should prove eye-opening to anyone vexed with a belt-killing transmission drive.

In 1922 the Edison Portland Cement Company called in the G. T. M.—Goodyear Technical Man—to recommend a belt for the Giant Roll Drive in their crusher plant at New Village, N. J.

This drive operates the great rock crusher that grinds up huge limestone boulders weighing from three to ten tons. The terrific shock and strain of such impacts required a belt with plenty of intestinal fortitude.

SPECIFIED BY THE G. T. M.

Thoroughly analyzing these requirements, the G. T. M. specified a 9-ply Goodyear Transmission Belt 147 feet long and 60 inches wide.

In 1926, after handling 650 to 850 horsepower loads continuously for four years, this belt had already given such unusual service that a company official stated: *"Its performance to date is really remarkable—it has never given a moment's trouble!"*

Today, eight years later—12 years after installation—this belt is still in service without ever having had one minute's "time out" for repairs, save cutting to take up slack. And it looks good for several years' more service!

Records like this are common where the G. T. M. has specified belting to fit exacting jobs. Perhaps he could save you money in equipment and operating costs. To get in touch with him, write Goodyear, Akron, Ohio, or Los Angeles, California—or your nearest Goodyear Mechanical Rubber Goods Distributor.

BELTS • MOLDED GOODS
HOSE • PACKING
MADE BY THE MAKERS OF GOODYEAR TIRES

THE GREATEST NAME IN RUBBER

GOODYEAR

WHEN YOU BUY PACKINGS *remember this*

BELMONT HOLLOW CENTER PACKINGS

Ring Form Belmont No. 19.
Spiral Form Belmont No. 319.
Coil Form Belmont No. 419.

Made of the finest quality closely woven rubber friction duck. The hollow center offers a point of least resistance, compensating for changes in expansion and contraction. Can be used for low and intermediate steam, hot and cold water rods and plungers, ammonia, steam hammers and elevator plungers.

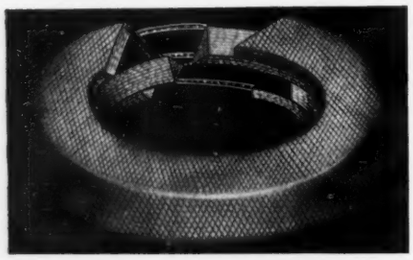
There Is a Belmont Packing for Every Service

THE BELMONT PACKING & RUBBER CO. — TRADE BELMONT MARK — PHILADELPHIA, U.S.A.

BELMONT EXPANSION PACKING

Ring Form Belmont No. 1.
Spiral Form Belmont No. 2.

This packing is constructed with sliding rubber and duck diagonal wedges, encased on three sides with rubber backed rubber and duck channel. It is *self adjusting* and can be used for hot and cold water, steam and ammonia services.



YOU place a tremendous responsibility upon the packings you use and the vital importance of the job they do is all out of proportion to their low cost.

Be careful to select the right packing for each service requirement. No matter what brand of packings you use, you cannot expect satisfactory results if the type of packing is unsuited to the purpose for which you choose it.

You cannot go wrong on Belmont. Your distributor's salesman will show you samples of the various types; and from the service recommendations section of his Belmont catalog, he will help you to select exactly the right packing for any service.

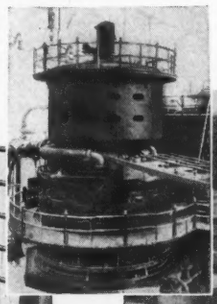
Belmont Packings are scientifically made of the finest materials by up-to-the-minute manufacturing processes and under the strictest kind of inspection. They accept the responsibility you place in them.

THE BELMONT PACKING & RUBBER CO.

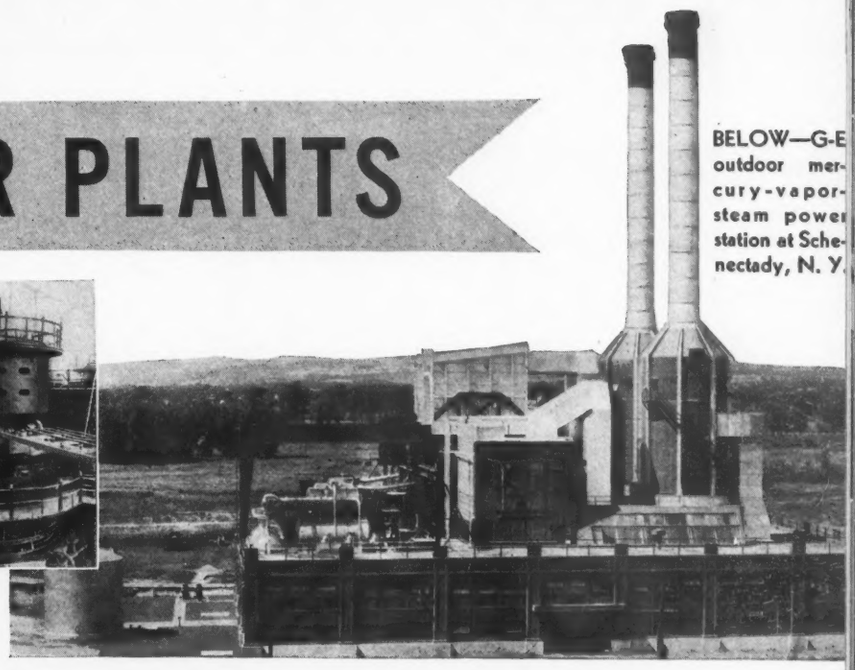
Butler and Sepviva Streets, Philadelphia, Pa., U. S. A.

"There is a Belmont Packing for every service"

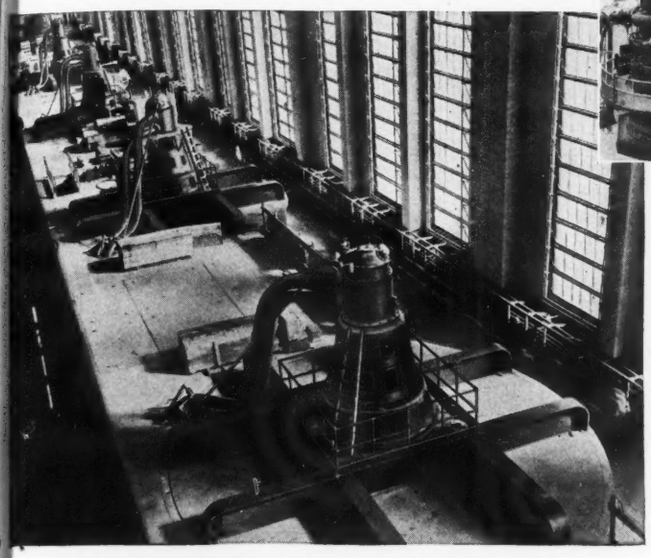
MODERN POWER PLANTS



RIGHT—Original 5000-kw. Curtis turbine installed at Chicago in 1903.



BELOW—G-E outdoor mercury-vapor-steam power station at Schenectady, N. Y.

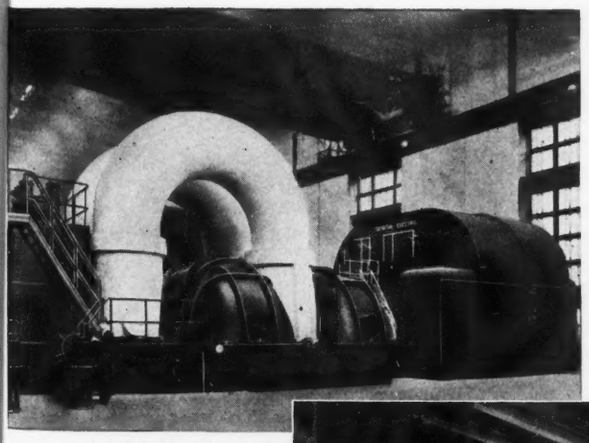


ABOVE—Four G-E vertical waterwheel-driven generators, each rated 31,111 kv-a., installed at Safe Harbor, Pa. A fifth unit is to be installed this year.

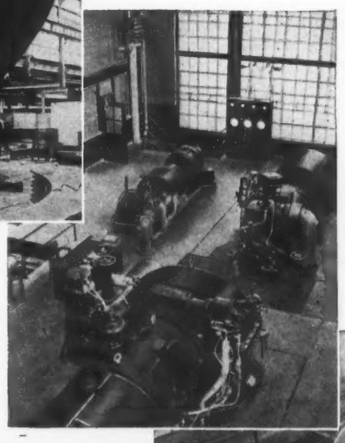
Thirty years separate the installations of the first General Electric turbine and the latest. Larger, more efficient units, built by General Electric, have succeeded the first, until to-day the seven modern plants illustrated here have been selected as typical examples of the best present-day American practice.

On the following pages is a selection of products that make modernization profitable. For further information on any of them, write the nearest G-E office, or General Electric, Dept. 6-201, Schenectady, N. Y.

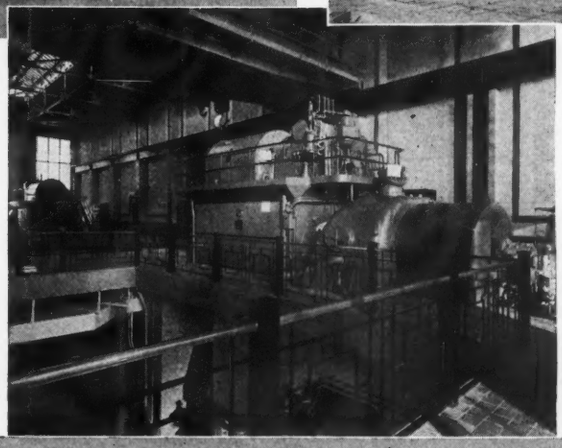
LEFT—Stator frame for one of the two G-E 82,500-kv-a. waterwheel-driven generators to be installed at Boulder Dam.



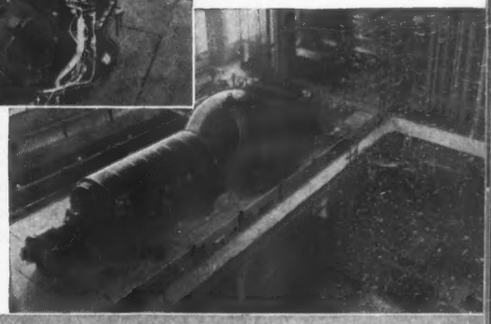
ABOVE—One of the two G-E 160,000-kw. steam-turbine-generators installed in the Hudson Ave. Station, Brooklyn Edison Co., Brooklyn, N. Y.



LEFT—G-E 2000-kw. condensing extraction turbine-generator at the Garfield (N. J.) plant of the Forstmann Woolen Co. Eleven G-E mechanical-drive turbines were installed as part of this plant's modernization program.



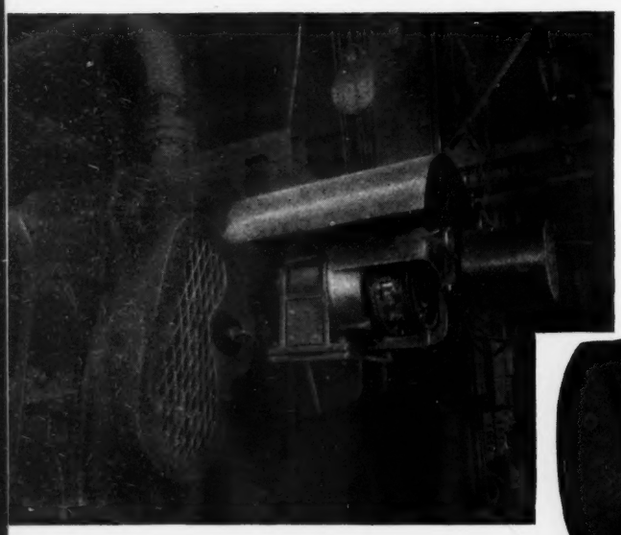
RIGHT—Two G-E 25,000-kw. steam-turbine-generator sets installed at South Amboy, N. J., for the Jersey Central Power & Light Co.



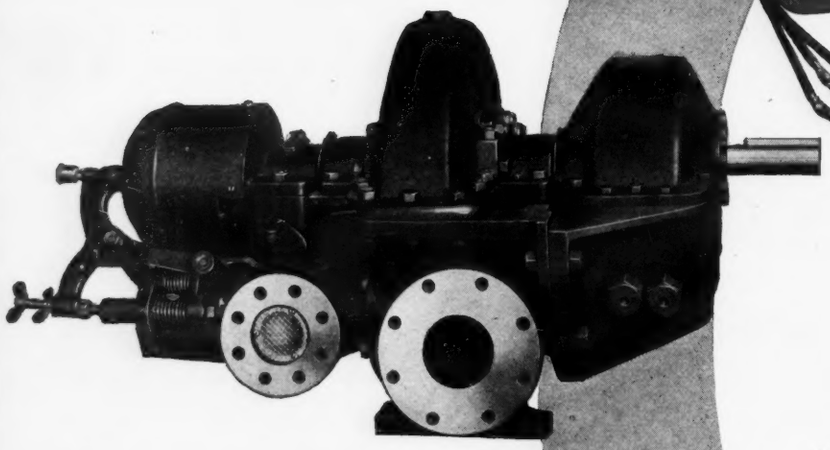
RIGHT—G-E 35,000-kw. steam-turbine-generator installed at the Buzzard Point station of the Potomac Electric Power Co.

GENERAL ELECTRIC

PRODUCTS THAT MAKE

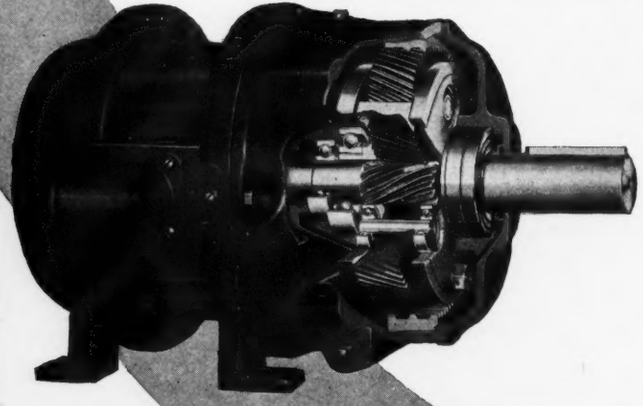


AN A-C. MOTOR WITH D-C. SPEED CHARACTERISTICS. The G-E Type BTA motor supplies the most desirable characteristics of a d-c. motor without investment in conversion equipment. Ask for Bulletin GEA-712B. LEFT—Type BTA motor driving a chain grate stoker. BELOW—G-E Type BTA motor.



GET THE MOST FROM YOUR STEAM. This new G-E gear-turbine combines a mechanical-drive turbine and a reduction gear for low-speed drives. Capacities from 10 hp. to 150 hp. Low initial, installation, maintenance, and replacement costs. Ask for Bulletin GEA-1855.

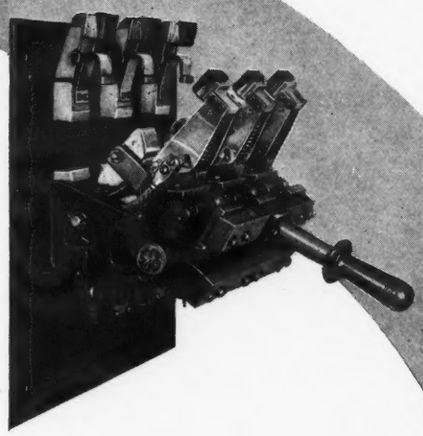
THIS MOTOR SAVES $4500 ANNUALLY. The Powhatan Mining Co. modernized a ventilating fan with this G-E 200-hp. synchronous motor and control, at a cost of $3258. The annual saving is $1500 through increased efficiency, and $3000 through improved power-factor.



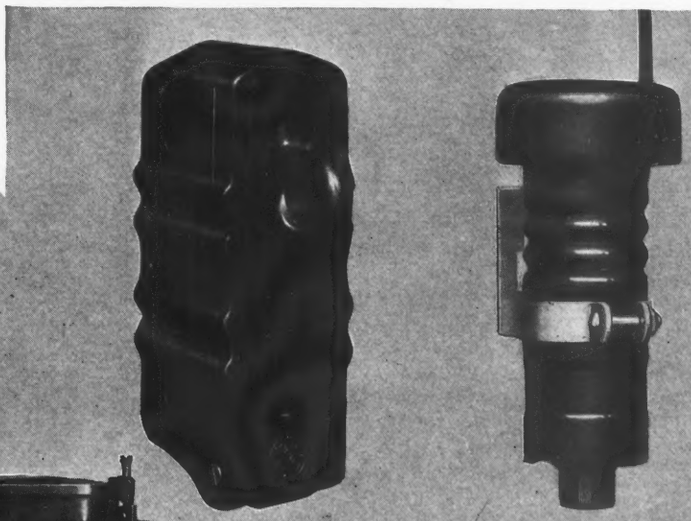
COMPACT, EFFICIENT, LOW-SPEED DRIVES. G-E gear-motors direct connected to your machines offer you the economies of a high-speed motor for low-speed drives. Ask for Bulletin GEA-1765. LEFT—G-E gear-motor driving cold amesite mixer. ABOVE—Cutaway view of typical 100-Series gears.

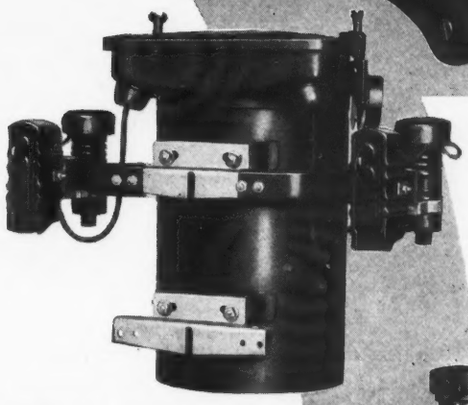
GENERAL

MODERNIZATION PROFITABLE



STRENGTH characterizes this new air circuit breaker—Type AL-2. G-E air circuit breakers are available in capacities up to 600 volts, 4000 amperes, alternating current, and 750 volts, 6000 amperes, direct current. G-E breakers have good contact characteristics and proved mechanical strength. Ask for descriptive information.



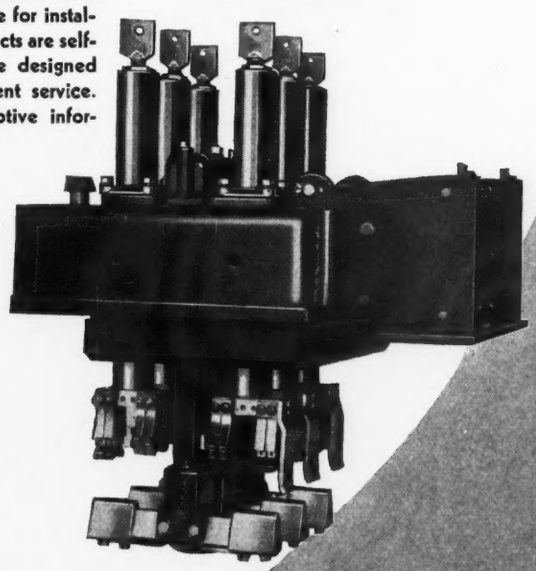


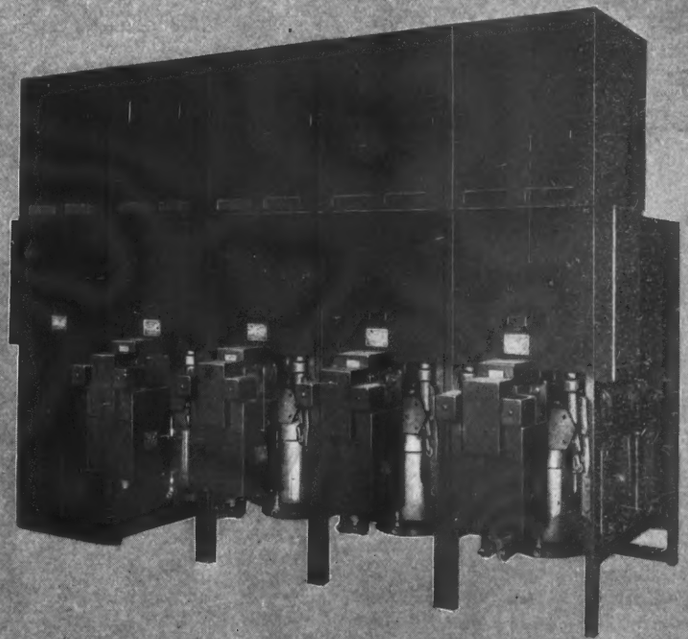
PROTECT YOUR DISTRIBUTION CIRCUITS—Individual over-voltage and short-circuit protection for distribution transformers is provided by G-E pellet arresters (above at right) and G-E porcelain-enclosed fuse cutouts (above at left). AT THE LEFT—A distribution transformer equipped for unit mounting with these devices.

RIGHT—G-E oil fuse cutouts will interrupt heavy short-circuit currents. They can be used underground or under water, near inflammable fumes, or where quiet operation is desired. Ask for Bulletin GEA-1673.

BELOW—METAL-CLAD, SHIPPED-ASSEMBLED SWITCHGEAR is easily installed, safe, and reliable. Maintenance cost is low. The need of detailed engineering on the part of the operating company is eliminated. Ask for Bulletin GEA-1661.

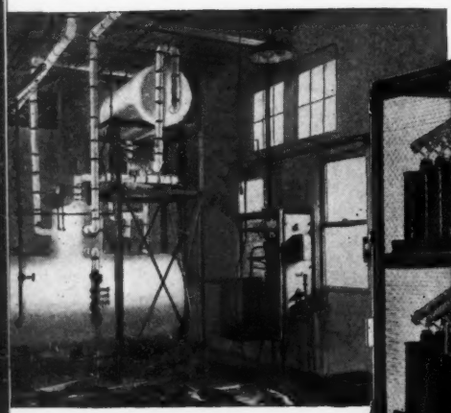
BELOW—OIL-BLAST CIRCUIT BREAKER. G-E breakers provide higher interrupting capacities and require less space for installation. The contacts are self-aligning and are designed for hard, frequent service. Ask for descriptive information.



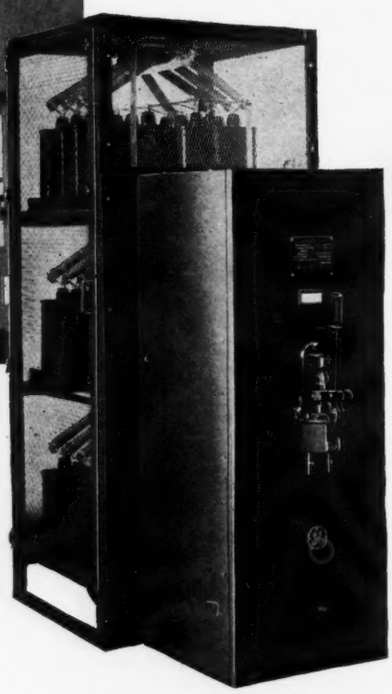


ELECTRIC

PRODUCTS THAT MAKE MODERNIZATION PROFITABLE



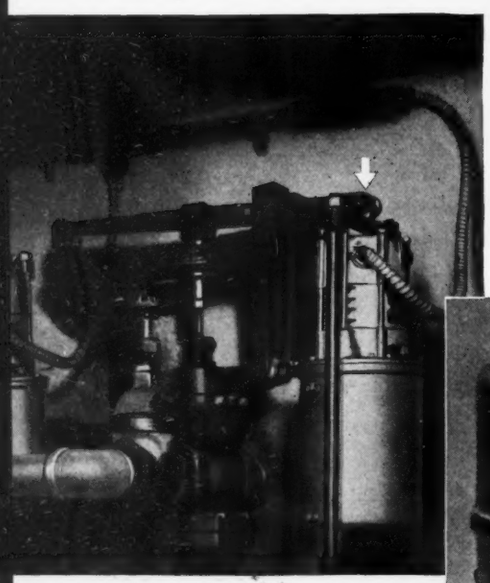
ECONOMICAL PROCESS STEAM from the G-E electric steam generator. This equipment provides adequate process steam, and eliminates expensive steam-plant upkeep during the summer months. Many installations have paid for themselves through savings during the first year. Ask for Leaflet GES-960.

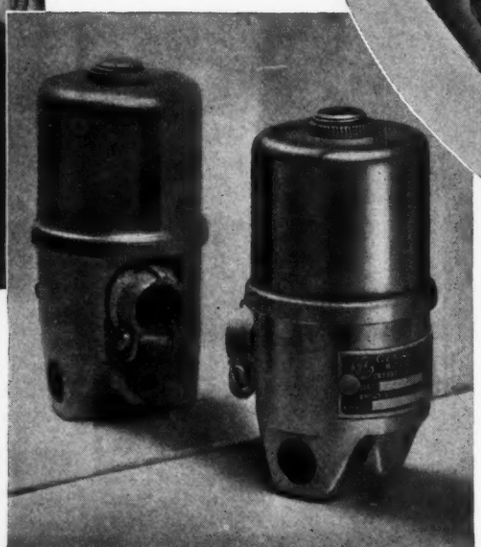


NEW GLYPTAL-CLOTH-INSULATED CABLE. This cable is resistant to oil, heat, and gasoline. It can be supplied in all types and sizes. Ask for Bulletin GEA-1746.

25% to 125% RETURNED on INVESTMENTS in G-E Pyranol capacitors. These capacitors require less space, are nonflammable, and can be installed in any location, indoors or outdoors. Ask for Bulletin GEA-77F.

CHECK YOUR PRODUCTION COSTS. These instruments are simple, dependable, inexpensive, and easy to use. Check these features—quick response, permanently constant elements, and easy-to-read scales. TOP—Ammeter for switchboard mounting. LEFT—Portable voltmeter. RIGHT—Portable recording wattmeter. Ask for descriptive information.





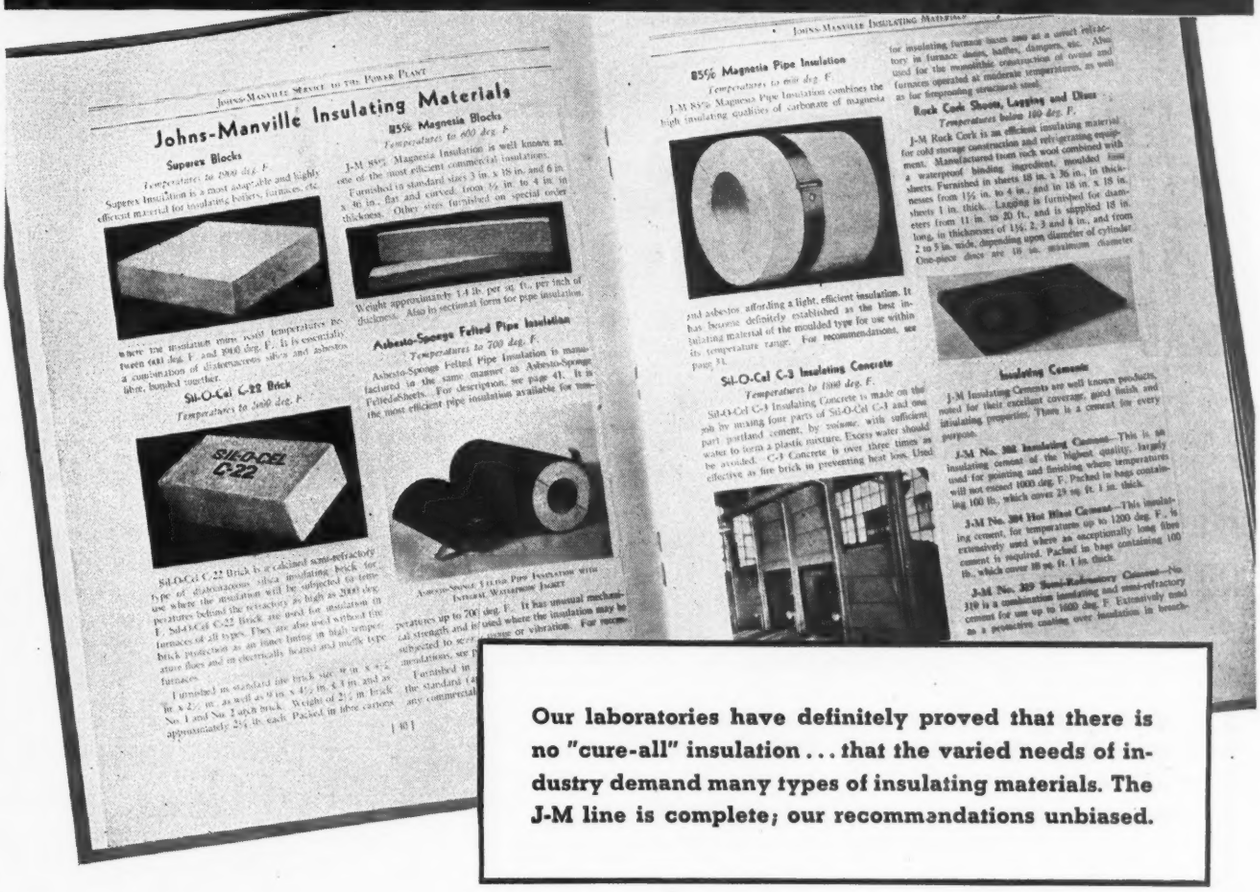
EW, COMPACT, electrically operated ALVES which operate according to anges in temperatures, pressures, vacums, or by clock mechanism. ABOVE—E Thrustor valves controlling a water stem. RIGHT—G-E solenoid valve for ndling water or low-pressure steam. Ask r Bulletins GES-848 and GEA-1847A.

96-58

GENERAL ELECTRIC

IF a few types of Insulation were adequate . . .

WE WOULDN'T MAKE 37



Johns-Manville Service to the Power Plant

Johns-Manville Insulating Materials

Superex Blocks

Temperatures to 2000 deg. F.

Superex Insulation is a most adaptable and highly efficient material for insulating boilers, furnaces, etc.

where the insulation must resist temperatures between 600 deg. F. and 1900 deg. F. It is essentially a combination of diatomaceous silica and asbestos fibre, bonded together.

Sil-O-Cel C-22 Brick

Temperatures to 3000 deg. F.

Sil-O-Cel C-22 Brick is a calcined semi-refractory type of diatomaceous silica insulating brick for use where the insulation will be subjected to temperatures behind the refractory as high as 2000 deg. F. Sil-O-Cel C-22 Brick are used for insulation in furnaces of all types. They are also used without fire brick protection as an inner lining in high temperature flues and in electrically heated and muffle type furnaces.

Furnished in standard fire brick size 9 in. x 4½ in. x 2½ in., as well as 9 in. x 4½ in. x 4½ in. and as No. 1 and No. 2 arch brick. Weight of 2½ in. brick approximately 2½ lb. each. Packed in fibre cartons

85% Magnesia Blocks

Temperatures to 600 deg. F.

J-M 85% Magnesia Insulation is well known as one of the most efficient commercial insulations. Furnished in standard sizes 3 in. x 18 in. and 6 in. x 36 in., flat and curved, from ½ in. to 4 in. in thickness. Other sizes furnished on special order.

Weight approximately 1.4 lb. per sq. ft., per inch of thickness. Also in sectional form for pipe insulation.

Asbesto-Sponge Felted Pipe Insulation

Temperatures to 700 deg. F.

Asbesto-Sponge Felted Pipe Insulation is manufactured in the same manner as Asbesto-Sponge FeltedSheets. For description, see page 41. It is the most efficient pipe insulation available for temperatures up to 700 deg. F. It has unusual mechanical strength and is used where the insulation may be subjected to severe vibration. For recommendations, see page

Furnished in the standard [illegible] any commercial

[40]

Johns-Manville Insulating Materials

85% Magnesia Pipe Insulation

Temperatures to 600 deg. F.

J-M 85% Magnesia Pipe Insulation combines the high insulating qualities of carbonate of magnesia and asbestos, affording a light, efficient insulation. It has become definitely established as the best insulating material of the moulded type for use within its temperature range. For recommendations, see page 31.

Sil-O-Cel C-3 Insulating Concrete

Temperatures to 1200 deg. F.

Sil-O-Cel C-3 Insulating Concrete is made on the job by mixing four parts of Sil-O-Cel C-3 and one part portland cement, by volume, with sufficient water to form a plastic mixture. Excess water should be avoided. C-3 Concrete is over three times as effective as fire brick in preventing heat loss. Used for insulating furnace linings and as a cement refractory in furnace doors, baffles, dampers, etc. Also used for the monolithic construction of ovens and furnaces operated at moderate temperatures, as well as for fireproofing structural steel.

Rock Cork Sheets, Lagging and Discs

Temperatures below 100 deg. F.

J-M Rock Cork is an efficient insulating material for cold storage construction and refrigerating equipment. Manufactured from rock wool combined with a waterproof binding ingredient, moulded into sheets. Furnished in sheets 18 in. x 36 in., in thicknesses from 1½ in. to 4 in., and in 18 in. x 18 in. sheets 1 in. thick. Lagging is furnished for diameters from 11 in. to 30 ft., and is supplied 18 in. long, in thicknesses of 1½, 2, 3 and 4 in., and from 2 to 5 in. wide, depending upon diameter of cylinder. One-piece discs are 18 in. maximum diameter.

Insulating Cements

J-M Insulating Cements are well known products, noted for their excellent coverage, good finish and insulating properties. There is a cement for every purpose.

J-M No. 302 Insulating Cement—This is an insulating cement of the highest quality, largely used for pointing and finishing where temperatures will not exceed 1000 deg. F. Packed in bags containing 100 lb., which cover 23 sq. ft. 1 in. thick.

J-M No. 304 Hot Blast Cement—This insulating cement, for temperatures up to 1200 deg. F., is extensively used where an exceptionally long fibre cement is required. Packed in bags containing 100 lb., which cover 18 sq. ft. 1 in. thick.

J-M No. 309 Semi-Refractory Cement—No. 310 is a combination insulating and semi-refractory cement for use up to 1600 deg. F. Extensively used as a protective coating over insulation in breech-

Our laboratories have definitely proved that there is no "cure-all" insulation . . . that the varied needs of industry demand many types of insulating materials. The J-M line is complete; our recommendations unbiased.

THROUGH 76 years the Johns-Manville line of insulating materials has kept pace with industry's requirements. Higher temperatures, more severe service conditions, have been met by improvements in existing Johns-Manville insulations, or the development of new ones.

Today the J-M line numbers 37 different industrial insulations. Recognizing the limitation of every basic insulating material, J-M employ those materials best suited for each specific job.

Maintaining a line so unusually complete, we are able to offer unbiased recommendations. We have no particular type, or types, of insulation to "sell" you. We can help you choose from all available varieties of insulation materials those that are proving most effective in reducing operating costs, increasing operating efficiency, under your particular working conditions.

Judge for yourself how completely we help you to utilize the desirable characteristics of all types of insulating materials. Ask for your copy of our modern insulation handbook written especially for the power plant.

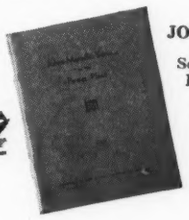
It contains recommendations covering types and thickness of insulation for your pipe lines, your high-temperature equipment of all types. It discusses the complete range of J-M Insulating Materials (Bricks, Blocks, Sheets, Blankets, Cements, Pipe Insulation, etc.) and describes their correct application.

Interestingly written, illustrated by scores of photographs, drawings and diagrams, it is *free*. Mail the coupon.

Johns-Manville

Industrial Insulations

For every temperature condition from 400° F. below zero to 3000° F. above.



JOHNS-MANVILLE, 22 East 40th Street, New York City

Send me a free copy of "Johns-Manville Service to the Power Plant."

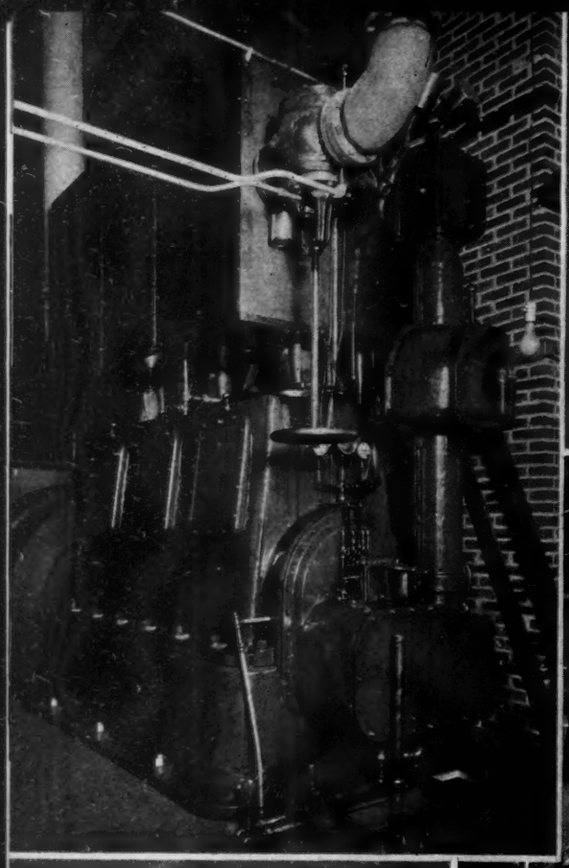
Name_____ Title_____

Firm Name_____

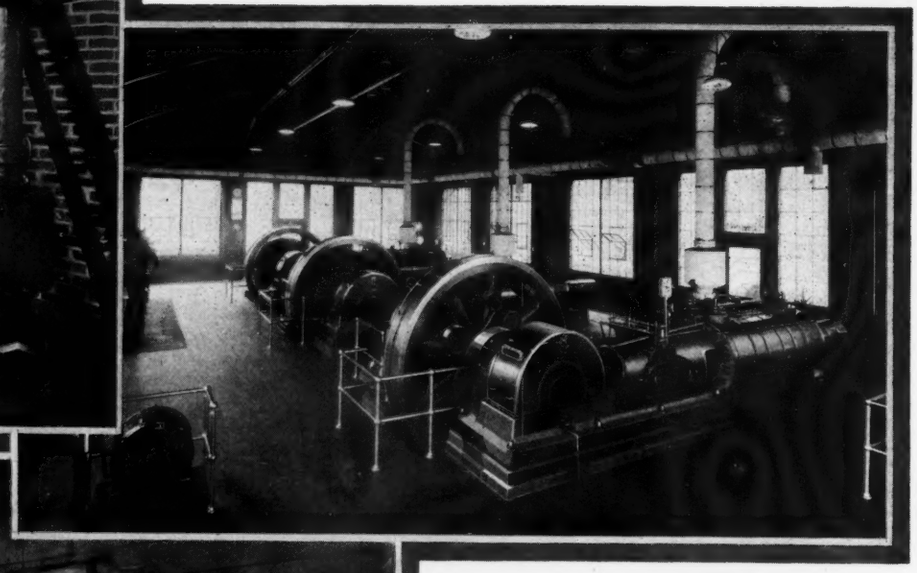
Address_____

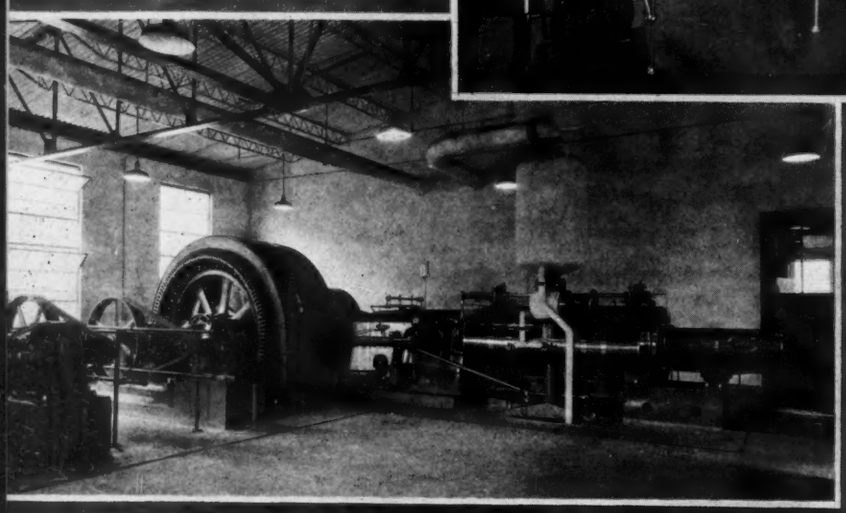
City_____ State_____

P-6-34

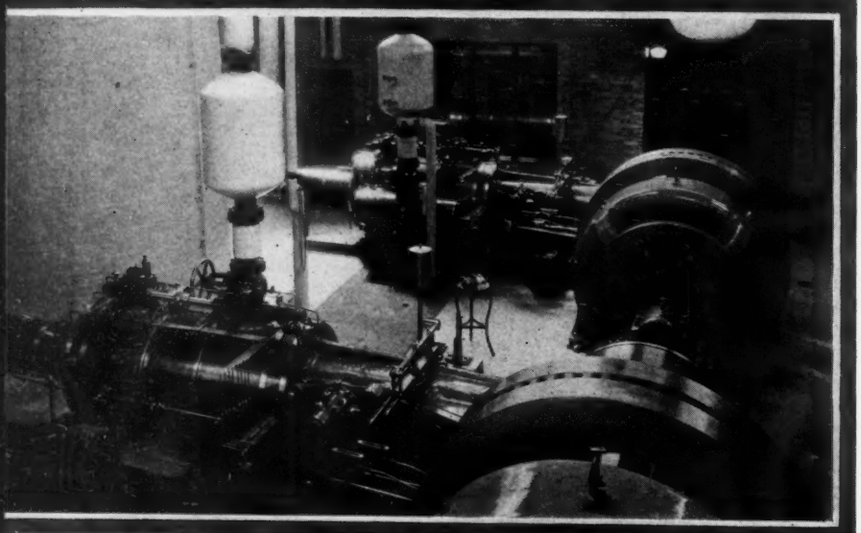


THROUGH 6





Since 1868

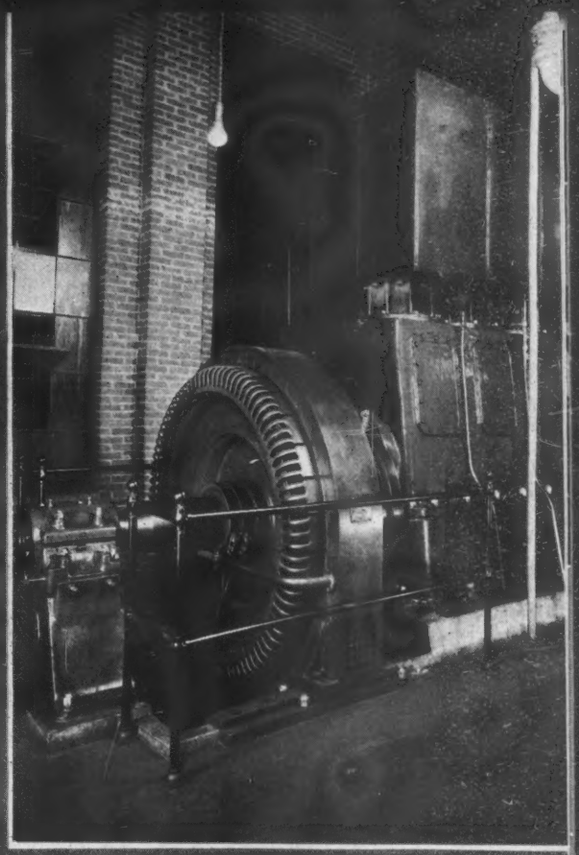


DOING ONE THING WELL . . .

Building STEAM ENGINES only

SKINNER ENGINE CO.

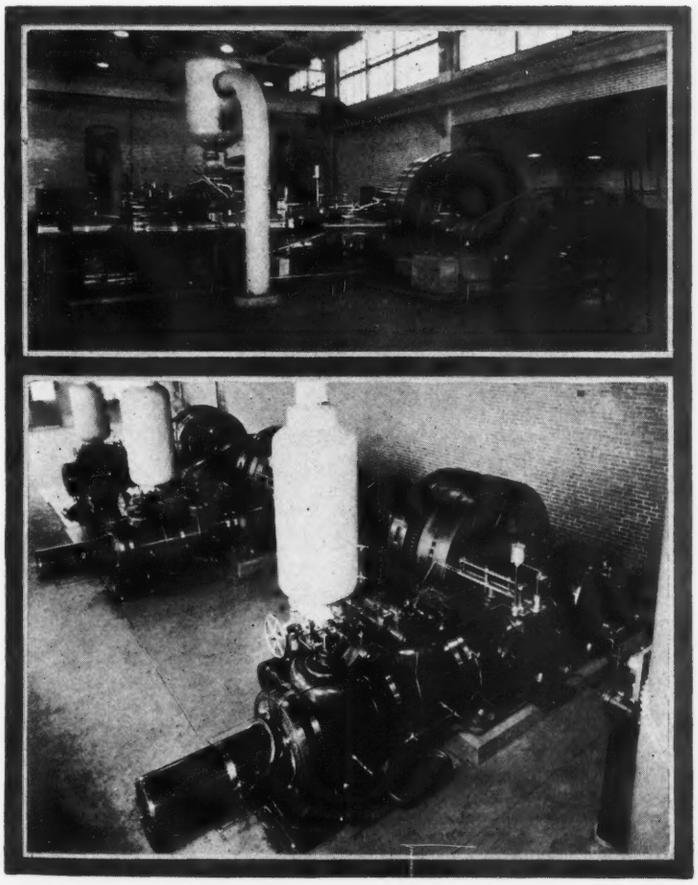
DECADES OF UPS AND DOWNS

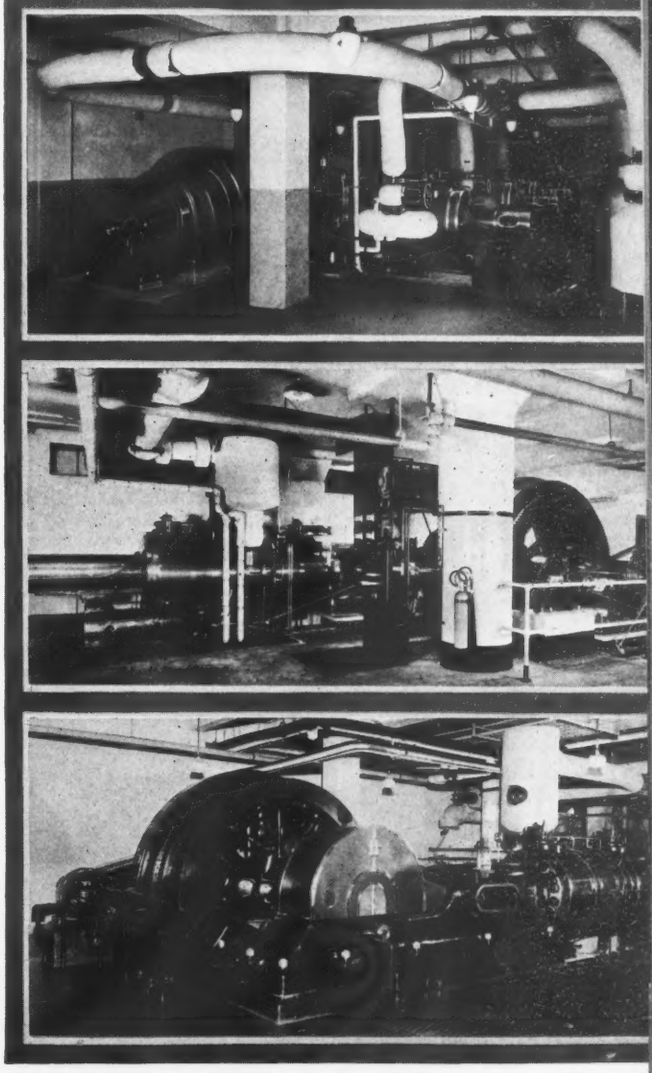


THE rise and fall of the business tide has not affected the prestige of the Skinner Engine Company. The same personnel of management, research and sales which functioned during the peak a few years ago is in operation today; also the same policy of building the best, price being a a secondary consideration to economy.

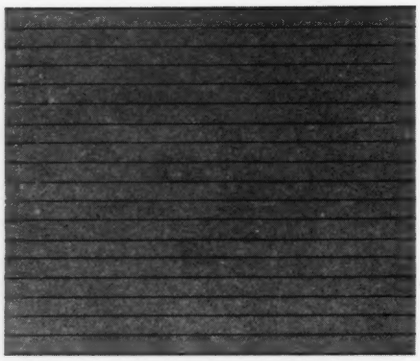
The supremacy of the "Universal Unaflow" engine is evidenced by the fact that approximately 50% of the total unaflow engine sales of the entire industry have been made by this company.

Nor has the policy of guaranteeing savings in power costs, through the installation of "Universal Unaflow" engines, been changed. Careful, conservative and responsible purchasers may still enjoy the benefits of the Skinner Guaranteed Savings Contract, by which the cost of engines and generators may be paid in savings effected.





ERIE, PENNSYLVANIA



THE PAST?

Let's forget it!

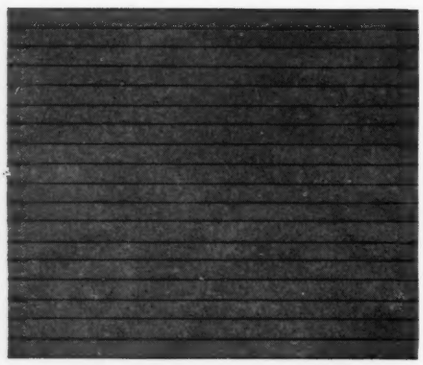
TOO many individuals and businesses are living in the past. They are looking backward instead of to the present and the future. Our experience of the last 38 years has exerted a profound influence upon Diamond equipment of today . . . there the importance of the past ends. It may be gratifying to reminisce on past achievements, but of much more value to the modern power plant is constructive thinking toward meeting the requirements of today and tomorrow.

THE PRESENT?

Our Chief Interest

INSTEAD of contemplating our accomplishments of the past . . . although they were of considerable importance to steam plant development . . . we are concentrating our efforts upon rendering a superior service to the steam power plants of today. More than 5000 modern boiler plants of all types and sizes will testify to the outstanding performance of Diamond products.

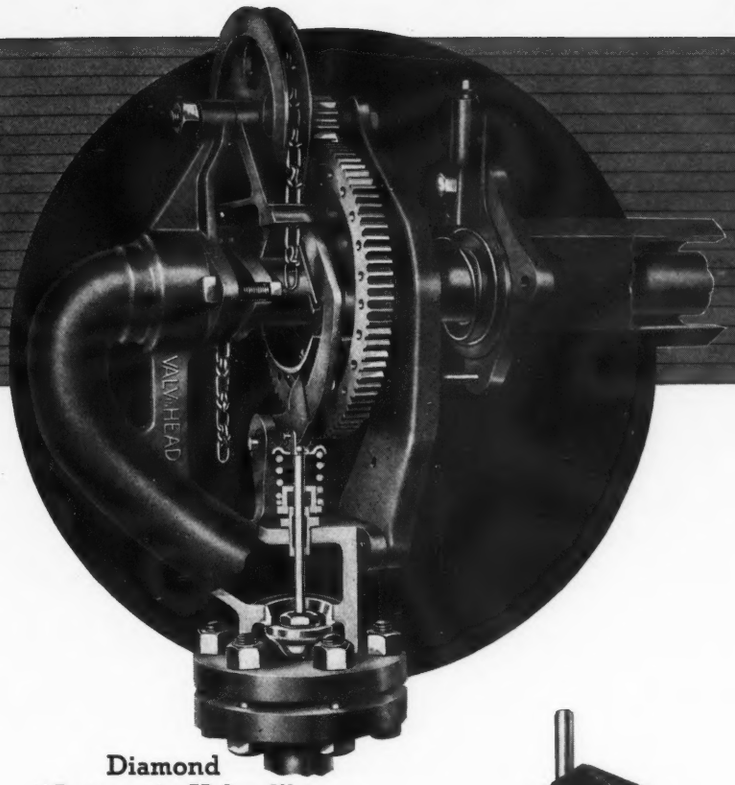
Illustrated here are only a few of the Diamond Products; others are: Deslaggers, High Pressure Water Columns, Automatic Air-Puff Soot Blowers, "Strait-Line" Soot Blowers (for H. R. T. Boilers), High-Low Water Alarms, Water Level Detectors, and Smoke Indicators.



THE FUTURE?

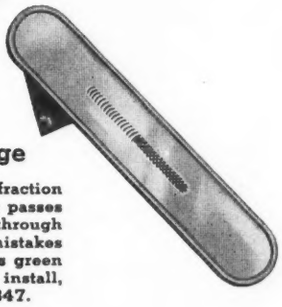
We will be ready!

IMPROVEMENTS on existing specialties and the development of new devices now under way in the Diamond Research Laboratory enable us to state with assurance that Diamond products of the future will meet the needs of the steam plant of tomorrow as completely as Diamond Soot Blowers and other Diamond products take care of today's requirements.



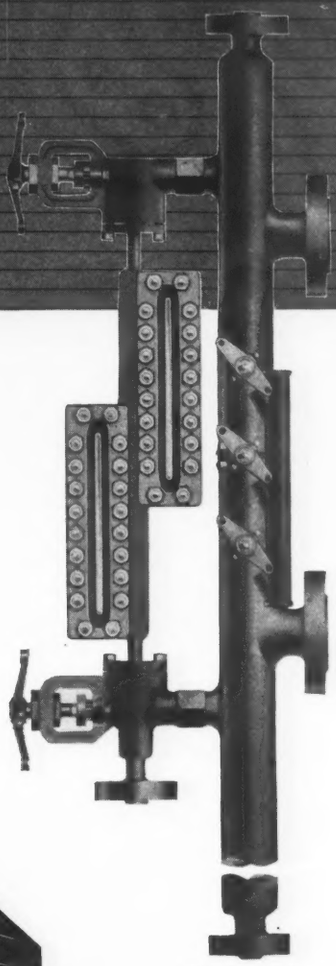
Diamond "Automatic-Valved" Soot Blowers

Save up to 50% of steam used by independently valved blowers; any required blowing arc up to and including 360°; blowing either clockwise or counter-clockwise according to gas flow; full or partial blowing pressure can be applied at any point of arc; gooseneck design provides unrestricted steam flow with minimum pressure drop; Calorized and Dialoy elements assure longest life; fewer parts and greater accessibility; precision workmanship and finest materials; free periodic inspection and instruction to operator. For all the facts, see Bulletin No. 347.



Diamond Bi-Color Water Gauge

Based upon the simple optical principle that the refraction (bending) of a ray of light is different when it passes through a column of steam than when it passes through a column of water. Reading difficulties and mistakes are eliminated because the water always shows green and the steam always shows red. Simple to install, accurate and dependable. See Bulletin No. 847.



Diamond "Loose Window" High Pressure Gauge

Designed so that bolting strain acts only on mica gasket assembly which leaves flat glasses free to expand and contract independent of steel gauge body having different coefficient. Mica that protects glass from watc. is finest obtainable to assure greatest visibility and emphasize the water level. This gauge is used in many of the leading high pressure power plants and has established an unequalled record for dependability and long life.

DIAMOND POWER SPECIALTY CORP.

DETROIT, MICHIGAN

DIAMOND SPECIALTY LIMITED

WINDSOR, ONTARIO

★ ★ ★ **during the**

we have widened our Service to Industry

★ Back in 1910 a small group of engineers dared imagine an electrically operated flow meter. Whoever may have conceived the same thought at the time, in whatever corner of the world, met practical barriers—acknowledged defeat—discarded the idea. The vision of which "Republic" is justifiably proud, refused practical limitations, saw through and beyond contemporary conditions, and glimpsed tremendous future benefits to a young industrial world. As is characteristic with true vision, wherever expressed, the

past three years

development has exceeded the dream in magnitude.

For 24 years Republic has been building *original* instruments. Now with its new flow meter featuring *"cartridge sealed elements,"* Republic again upsets standardized patterns. From an engineering stand point, the 1934 Republic instrument is radically new and thoroughly different—is literally years ahead of its time in many vital features.

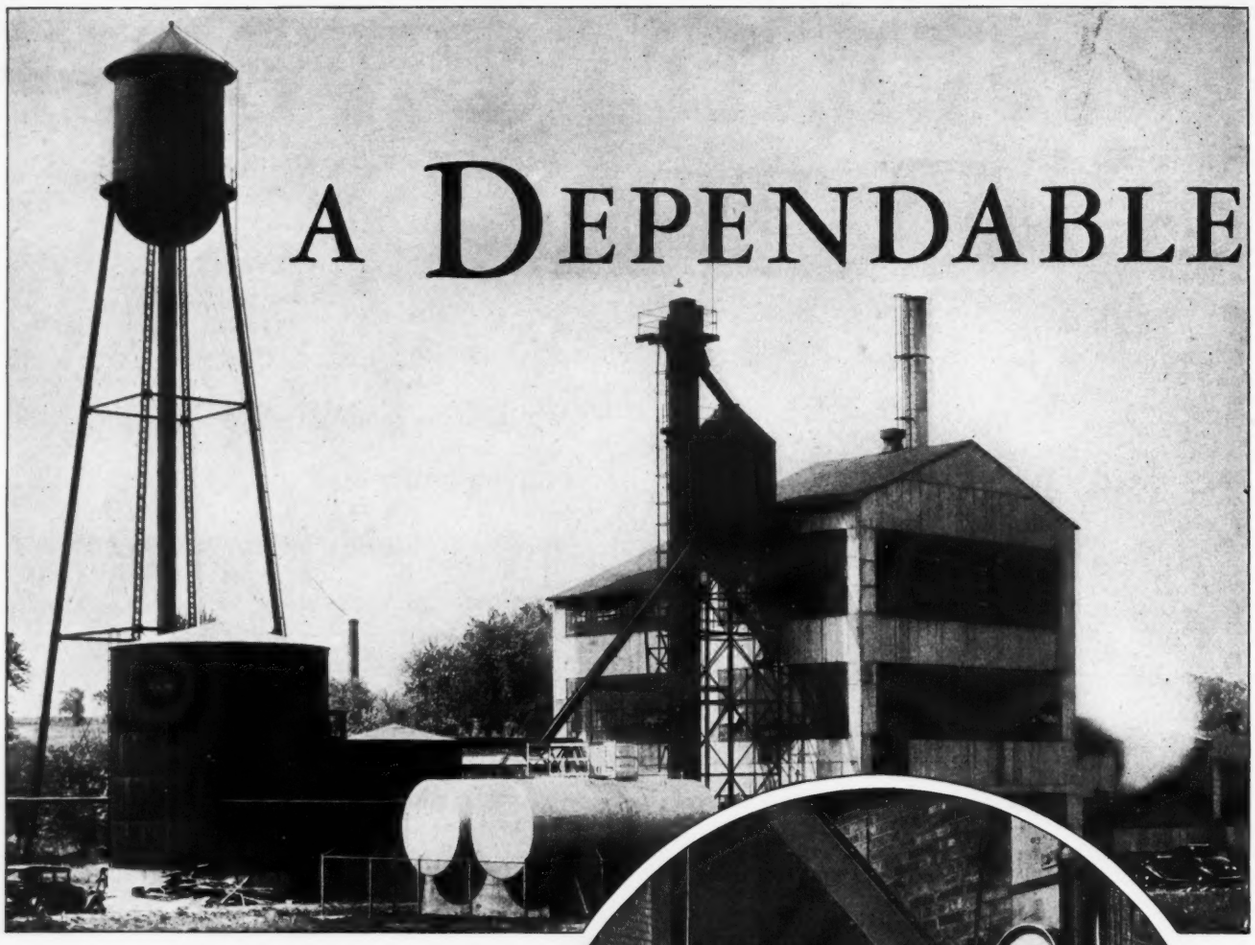
The spirit which pervaded this small group of engineers back in 1910 still lives—a vital inspiring force. During the past three years, to insure sound, progressive engineering, Republic has enlarged its research facilities, and brought together an even larger staff of engineers whose joy lies in accomplishment — whose ambition is to contribute some new advancement in the industrial instrument field.

Early in 1934 "Republic" announced a further widening of its service to industry. The Smoot Engineering Corporation, one of the leading designers and builders of control equipment, has joined forces with the Republic Flow Meters Co., bringing to industry, an organization capable of rendering a greater and more complete service in the field of measurement and control.

We look forward to congratulating "Power" again when it reaches the century mark and "Republic" is a ripe young seventy-four.

REPUBLIC FLOW METERS COMPANY
AND SMOOT ENGINEERING CORPORATION
General Offices, 2222 Diversey Parkway, Chicago, Illinois

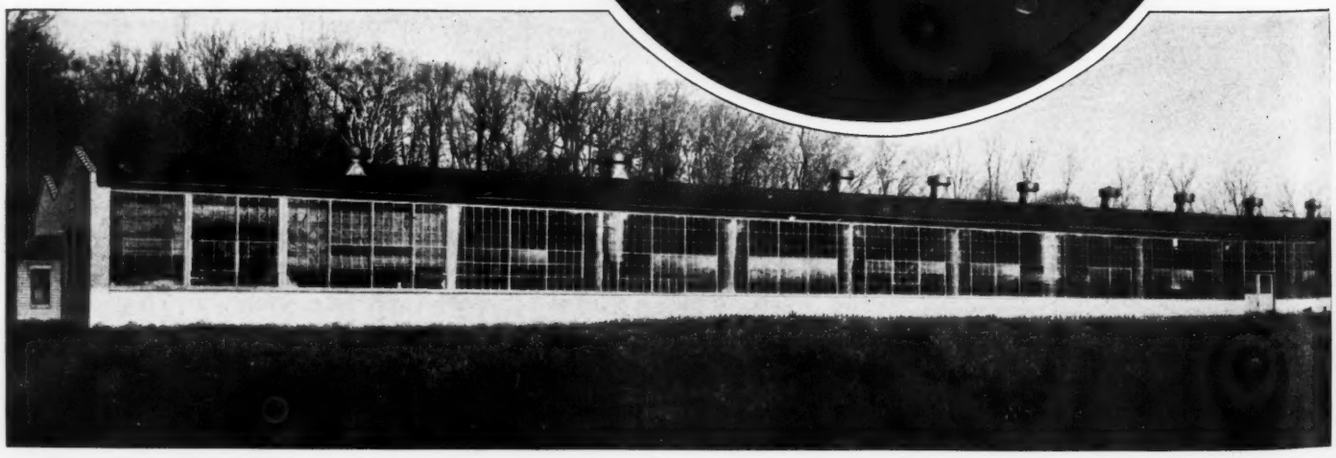
A DEPENDABLE



(*Above and below*)—Views of the Betzwood, Pa., Plant of Taylor and Company, Inc. Norristown, Pa.

★

(*Circle*)—Interior view of the Power Plant showing Westinghouse Stoker.



STOKER ... *judged by its Operating Record*

TAYLOR and Company, Inc., Norristown, Pa., manufacturers of vulcanized fibre and phenol fibre products, placed their Westinghouse Stoker in regular service March 25, 1933.

The plant operating record shows no interruption in production due to stoker outage.

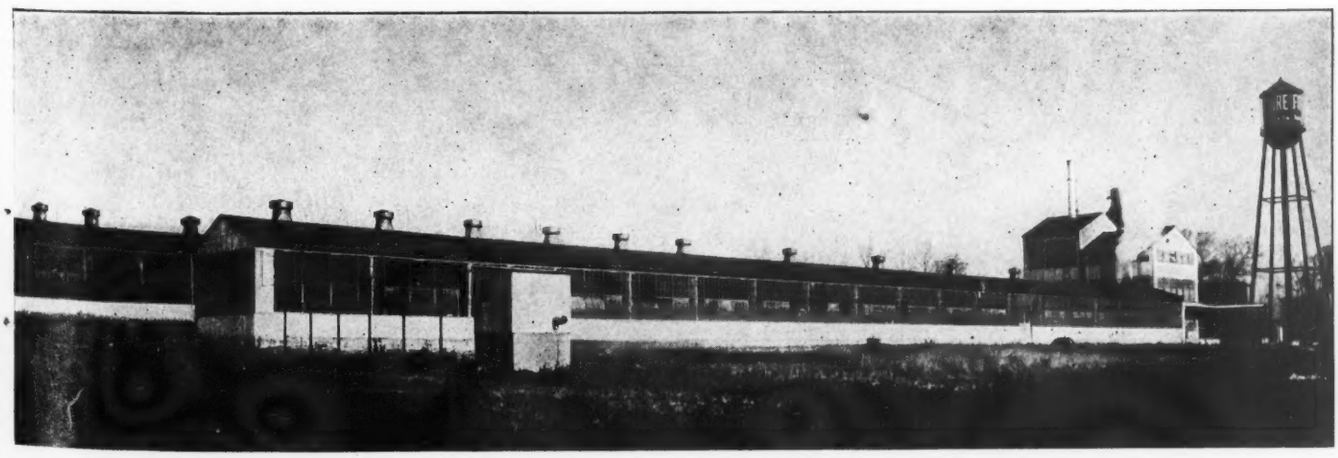
During this 14-month period the stoker burned 4158 tons of coal.

This one boiler unit carries the entire plant load, there being no standby unit.

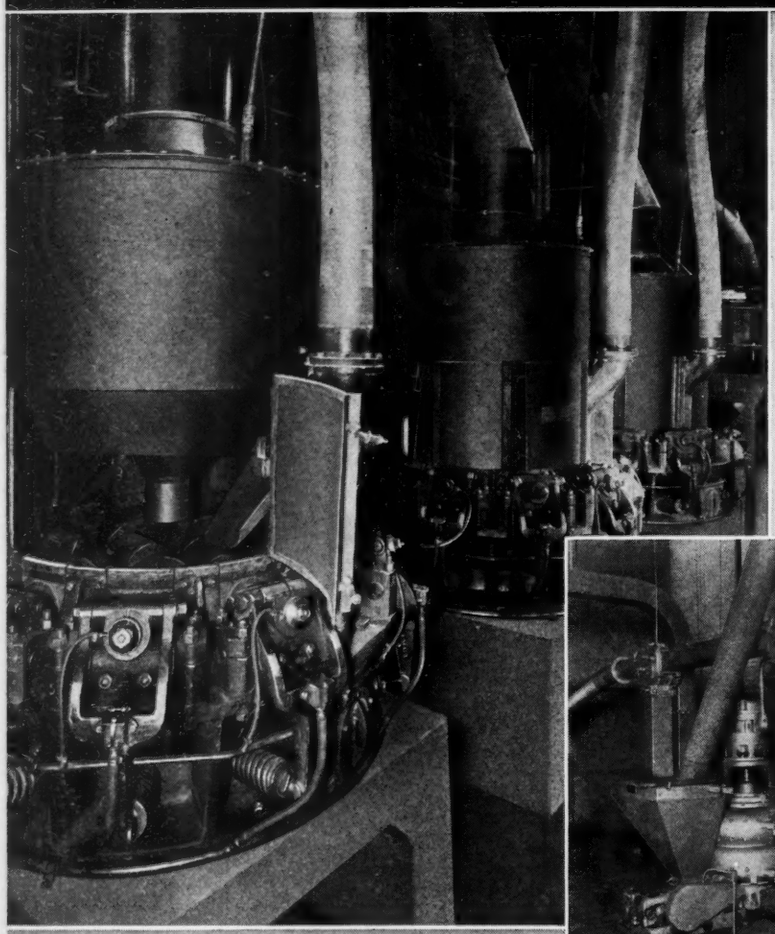
Such service testifies to the dependability of Westinghouse Stokers. T 85081

Westinghouse

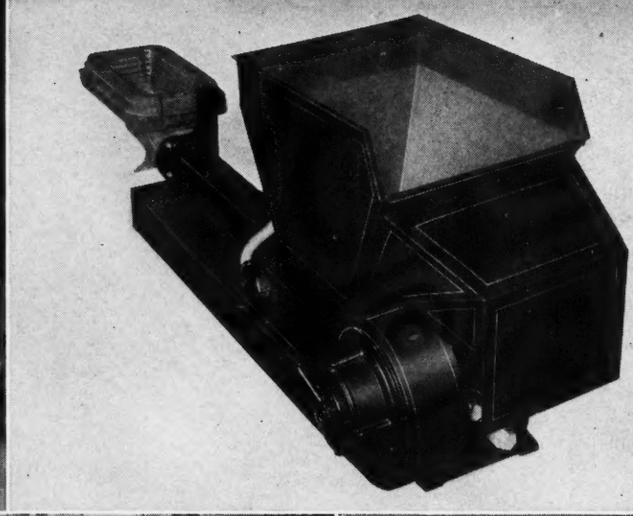
Stokers



50 YEARS OF SERVICE

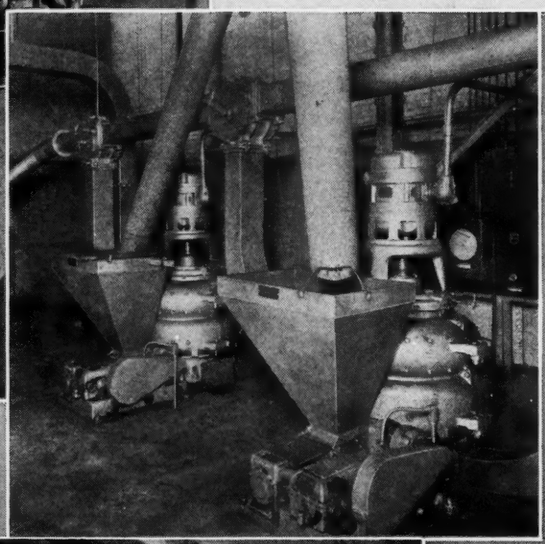


Battery Whiting Table Roller Pulverizers in a Central Station. Exceptionally low in maintenance and power cost. Capacities of 3 to 12 tons coal per hour.



Whiting Underfeed Stoker, Commercial type. Capacities up to 1250 pounds per hour. (Also Domestic Underfeed Stokers of various sizes.)

●



Two Whiting Impact Pulverizers, Froedtert Grain & Malting Co., Winona, Minn. Air Separation. Capacities: 50 to 3000 pounds per hour.

Three Whiting Horizontal Compression Feed Stokers, Model A. The Illinois Eye, Ear and Nose Hospital, Chicago, Ill. Overhead Fans save space.

FOR 50 YEARS

Whiting Corporation has been manufacturing power plant machinery, a line which now includes:

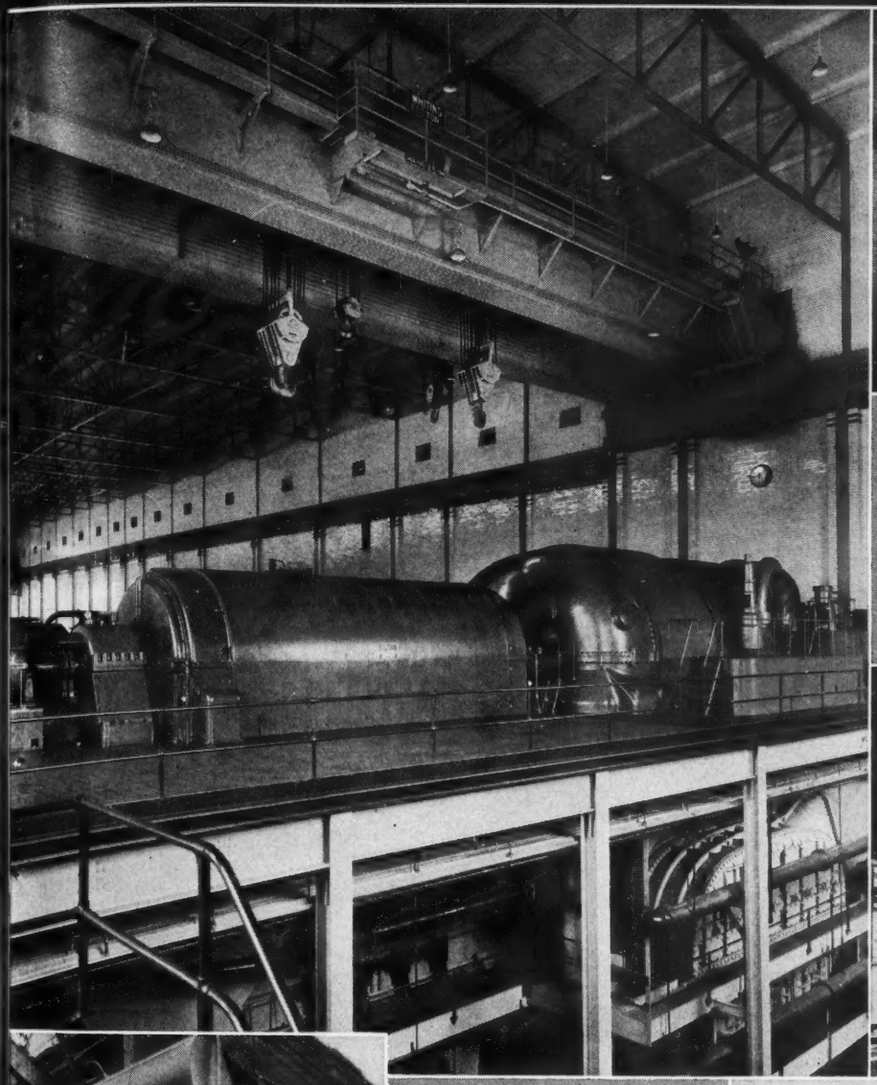
- ***Cranes*** .. { Turbine Room and Coal Handling, etc.
- ***Stokers*** .. { Progressive Combustion for Boilers up to 1000 H. P.—Screw-type Underfeed for small boilers.
- ***Impact Type Pulverizers*** { High Speed Impact Machines for the Smaller Plants.
- ***Table Roller Pulverizers*** { Lowest Maintenance and Power Costs for the Industrial Plant or Central Station.

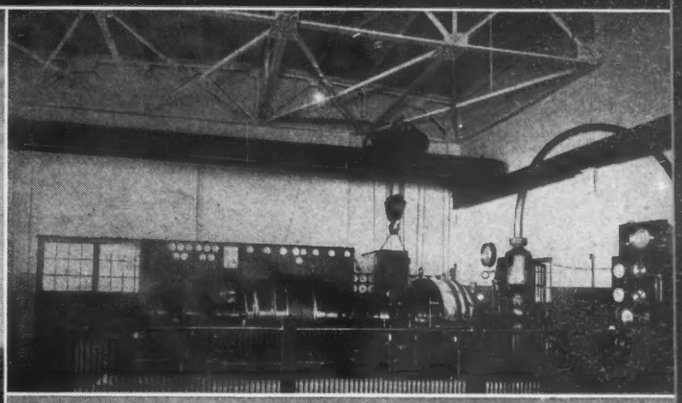
Also:

Complete Coal Pulverizing and Conveying Systems • Foundry Equipment • Railroad Specialties • Evaporators and Chemical Plant Equipment • Special Machinery.

WHITING POWER

TO INDUSTRY • 1884-1934

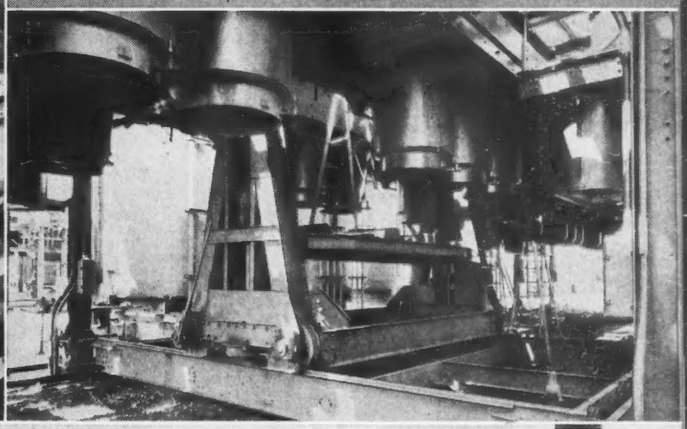


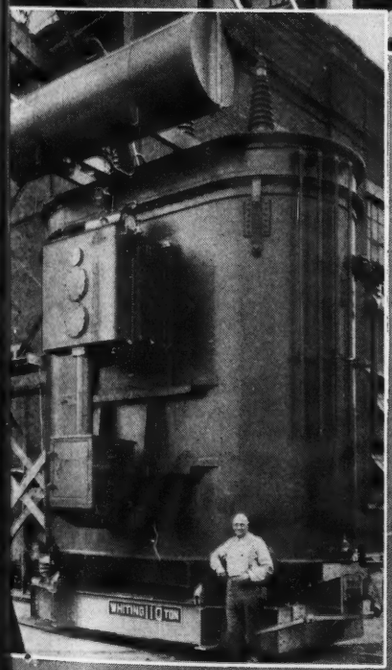


Whiting 15-Ton Hand Power Traveling Crane. Widely used in small power plants. Easily electrified.

●

Whiting Oil-Circuit-Breaker Hoist used to lift batteries of cement breakers. State Line Generating Co., Hammond, Ind.



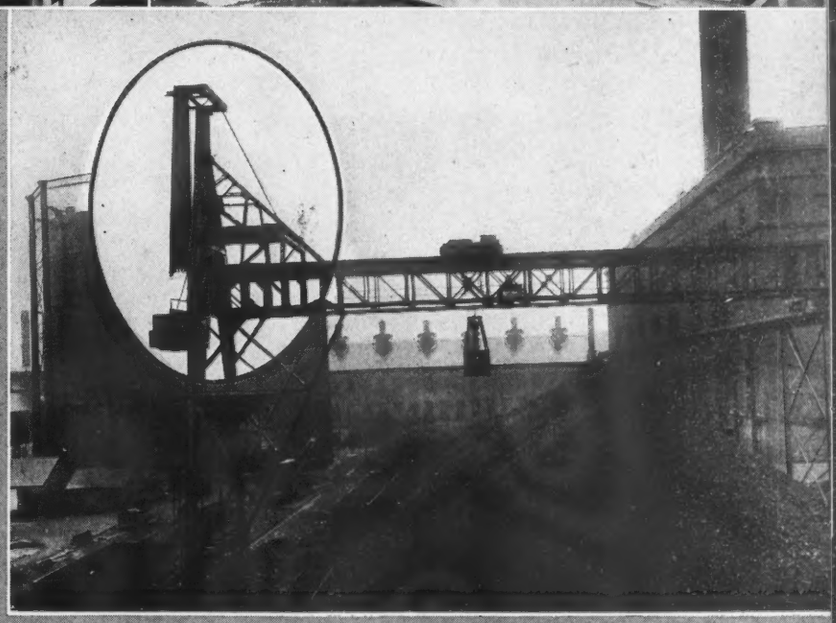


Whiting Transformer Truck, 110-Ton Capacity, in Power Plant service.

Whiting 250-Ton Power House Crane in a large modern Central Station. Span 133', Lift 65'.

●

Special Whiting Gantry Crane for coal handling. Union Gas & Electric Co., Cincinnati, Ohio. Span 138' 9"—Cantilever (raised to clear gas holder) 43' 9".



NRA

WHITING CORPORATION

15657 Lathrop Avenue Harvey (*Chicago Suburb*), Illinois

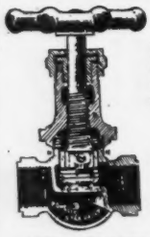
HOUSE EQUIPMENT

1846 TO 88 YEARS OF

This is how we advertised in 1884

We reproduce below our first advertisement in "Power," which ran in the first issue ever published.

Powell's Patent Star Regrinding Globe Valves and Star Sight Head Lubricators.



THE VERY BEST SURPLUS AND CHEAPEST GOODS OF THE KIND IN THE WORLD.

Engine Builders' BRASS WORK of every description.

WM. POWELL & CO.,
50, 52 and 54 Plum Street,
CINCINNATI, O.

The Wm. Powell Co. is one of 10 advertisers still in Power who started with Power's first issue in 1884.

1884 TO 1934
QUALITY VALVES

If Powell Valves were not a quality product, The Wm. Powell Company certainly could not have lasted so far toward the century mark. Only a company which gives satisfaction to customers can weather the storms of so long a period as 88 years.

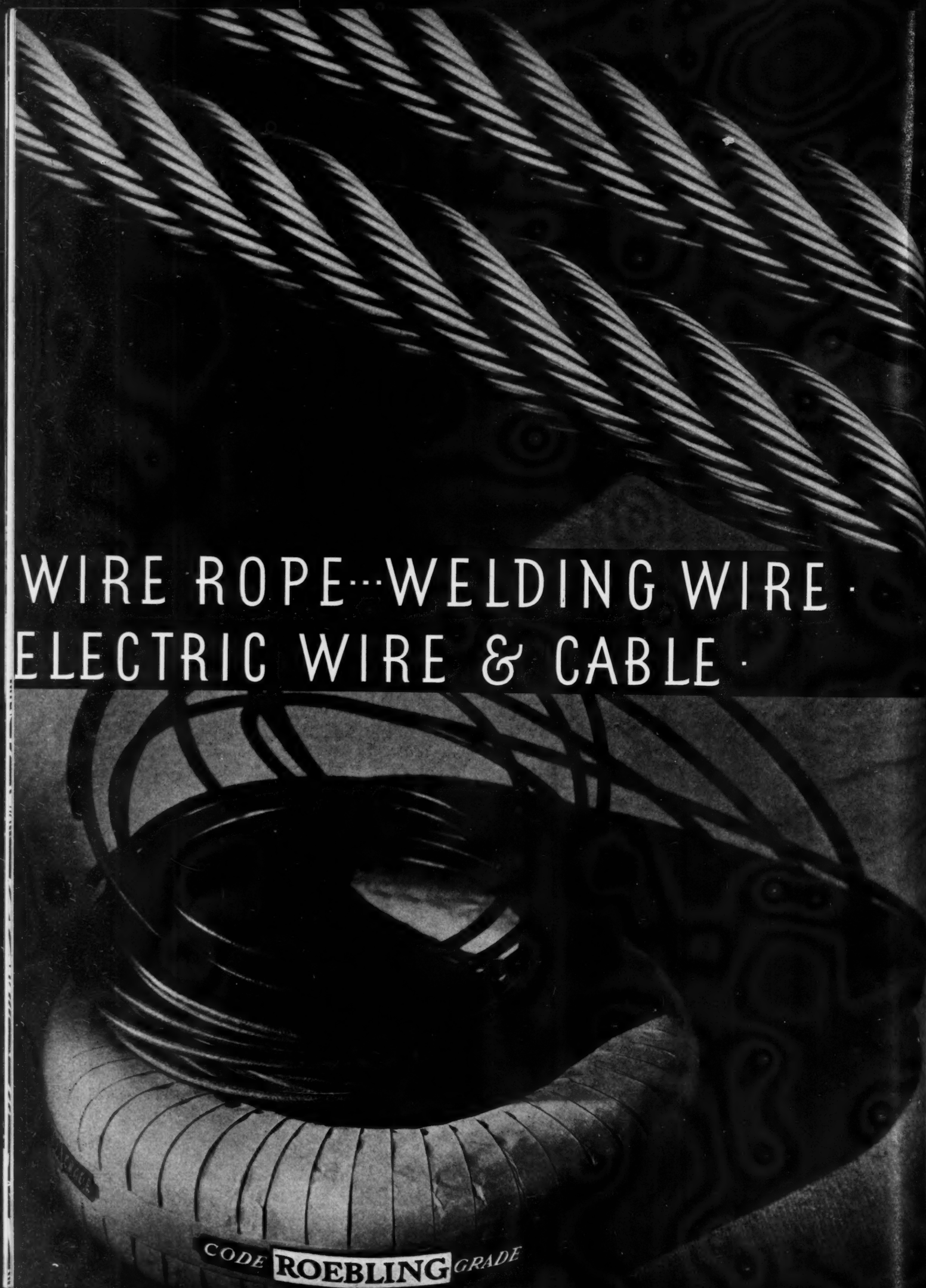
We were among those present at the birth of "Power" Magazine—had our advertisement in the first issue published. Even then we were an established concern of nearly 40 years' experience in supplying the right make to the engineer — experienced in keeping pace with the many developments which had already taken place in steam power.

We have seen the slide valve engine give way to the Corliss—watched the Corliss develop into a majestic Goliath which was promptly slain by a bustling little David—the turbine.

What next? Who knows? The turbine is now a giant which dwarfs the mightiest Corliss. But whatever is next, it will need valves and, as always, Powell will have the right valves for the job.

THE WM. POWELL COMPANY, 2521-31 Spring Grove Ave., Cincinnati, O.

POWELL
VALVES


WIRE ROPE···WELDING WIRE·
ELECTRIC WIRE & CABLE·
CODE ROEBLING GRADE

ONLY A FINE PRODUCT MAY BEAR THE NAME

ROEBLING

JOHN A. ROEBLING'S SONS COMPANY
TRENTON, NEW JERSEY.

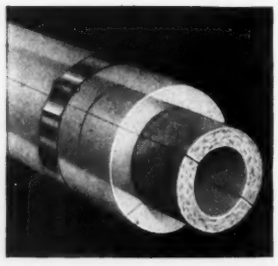
Carey
61 Years of
INSULATION
PROGRESS

. . . Cut
WITH CAREY

CAREY ALUMINO-HI-TEMP

For Furnaces, Ovens, Kilns, Etc.
1000° F. to 2500° F.

Carey Alumino-Hi-Temp blocks and bricks are designed for use as the heat insulating medium in ovens, furnaces, kilns, lehrs, regenerator chambers, breechings, ducts, etc., where internal temperatures run as high as 2500° F. or higher. Alumino-Hi-Temp is essentially a processed bauxite high in alumina content and having unusually high heat resistance and heat insulating efficiency.



CAREY HI-TEMP No. 12

For Superheated Surfaces
500° F. to 1200° F.

Hi-Temp No. 12 is an insulating covering consisting of a combination of heat resisting and insulating materials, bonded with asbestos, for use on high temperature surfaces where maximum heat saving is required. It is specifically designed for use on superheated steam and hot oil lines, oil stills, ovens, boiler breechings, furnace walls and similar surfaces.

CAREY 85% MAGNESIA

For High and Medium Pressure
200° F. to 550° F.

Carey 85% Magnesia is a molded composition of not less than 85% basic carbonate of magnesia and approximately 15% asbestos fibre. It is the highest quality molded heat insulation obtainable for medium and high pressure steam pipes and surfaces. It is furnished in sections and segments for covering pipes.

CAREYCEL INSULATION

For Temperatures up to 300° F.

Careycel is provably the most economical heat insulation of its type yet developed for this temperature range which covers the hot-water heating field and also steam lines carrying not over 100 lbs. pressure per square inch. Tests show it cuts heat losses 30% over ordinary Air Cell, yet it sells in same price range.

CAREY HEAT INSULATIONS

85% Magnesia Pipe Coverings
85% Magnesia Blocks
85% Magnesia Cement
Hi-Temp No. 12 Pipe Coverings
Hi-Temp No. 12 Blocks
Hi-Temp Cement
Alumino Hi-Temp Cement
Careycel Pipe Covering
Careycel Blocks
Laminated Asbestos Pipe Coverings
Laminated Asbestos Blocks
Corrugated Asbestos Pipe Coverings
Corrugated Asbestos Blocks
A-I Insulating Cement
Asbestos Cements
Thermalite Blocks
Vitrocel Stack Lining
Dicalite Insulating Powders
Rock Wool Blankets

Power Costs

SUPER-EFFICIENCY HEAT INSULATIONS

For more than a half century, The Philip Carey Company has been blazing trails of Progress in the insulation field. Through the Research Fellowship sponsored by Carey at the famous Mellon Institute at Pittsburgh, basic laws on heat transmission have been discovered and translated into usable formulae. Guesswork has been replaced by established facts. Today Carey produces heat insulations of asbestos, magnesia and alumina in various combinations—scientifically designed to insure highest efficiency of equipment carrying temperatures up to 2500°F. Thousands of Carey installations in the foremost industrial plants of America pay eloquent tribute to Carey Leadership.

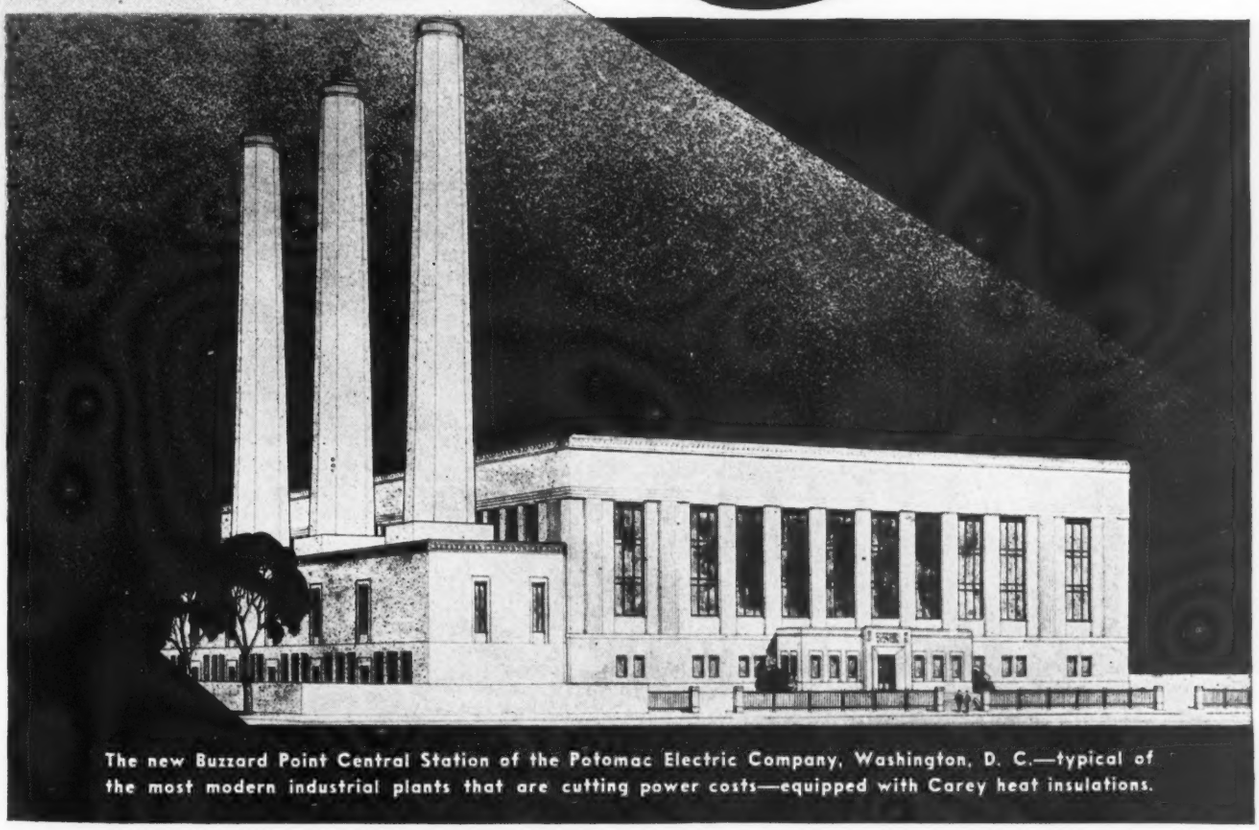
You can best meet today's highly competitive conditions with a modernized plant. Our engineers, without obligating you in any way, will gladly determine the definite economies that Carey insulations may effect in your plant.

Department 5

THE PHILIP CAREY COMPANY

Main Offices, Lockland, Cincinnati, Ohio • Branches in Principal Cities

Carey
EST. 1873

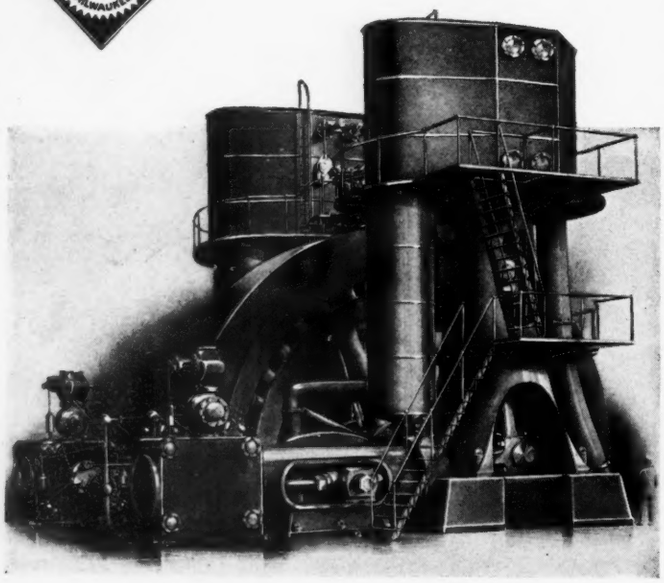


The new Buzzard Point Central Station of the Potomac Electric Company, Washington, D. C.—typical of the most modern industrial plants that are cutting power costs—equipped with Carey heat insulations.

Power
1884

THE IMPROVED REYNOLDS CORLISS ENGINE
OVER 500 IN USE.
UNEQUALLED FOR
Simplicity, Durability, Regularity and Economy
Especially adapted for Manufacturing Purposes
Blowing and Pumping Engines a Specialty.
Send for Descriptive Catalogue and Prices.
EDW. P. ALLIS & CO., Sole Manufacturers,
RELIANCE WORKS, Milwaukee, Wis.

Historical Achievements in Power Generation *during more than 70 years*



MANHATTAN ENGINES — Seventeen 12,000-hp Vertical-Horizontal Compound Engines. Cylinders 44″ and 88″ x 60″. First built in 1901 for Manhattan Railway Co. and New York Rapid Transit Co. (the Subway). The apex of engine construction.

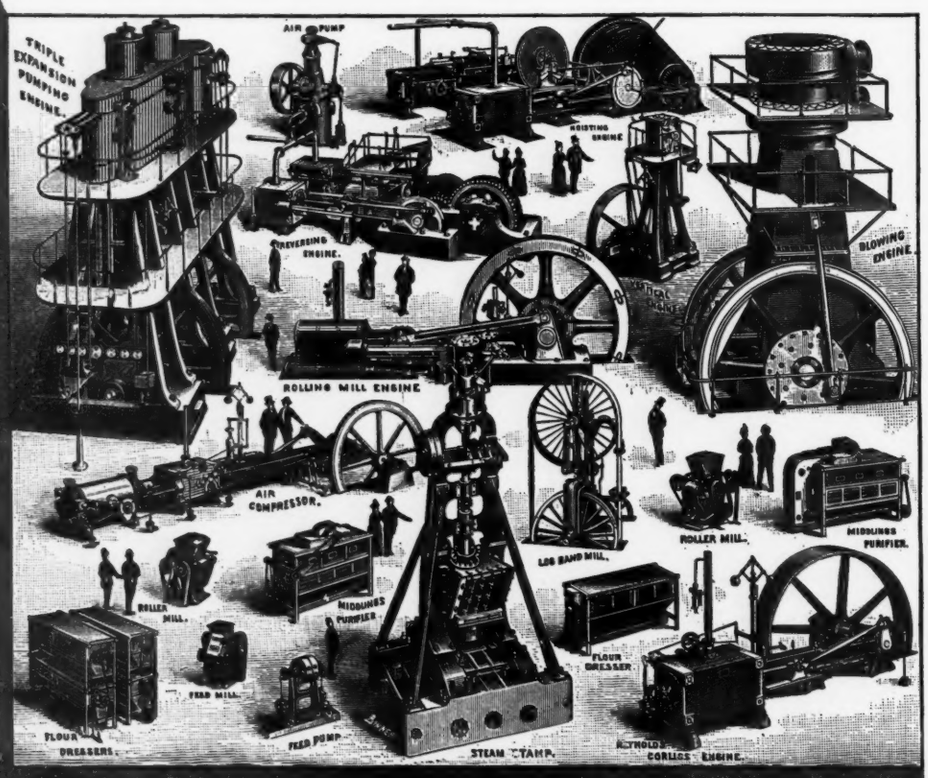
THE history of power generation centers around its engineers, men who had the courage to pioneer in the solution of engineering problems. The great advance during the past half century has been phenomenal.

Allis-Chalmers and its predecessor companies have had an important part in these achievements, with an unbroken record of more than seventy years in building power equipment and a much longer period for certain other types of machinery.

During this period the Company has built more than eleven million horsepower in steam power equipment, more than six million horsepower in hydraulic turbines and over half a million horsepower of internal combustion engines.

Many of these installations have established world's records for size, reliability and economy. Beginning thirty-five years ago, many installations have also included electrical equipment as well as prime movers.

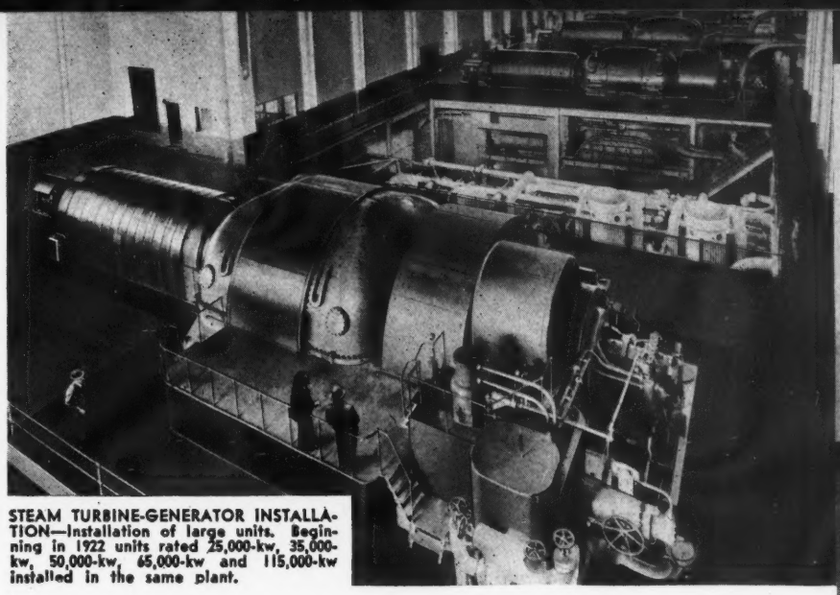
Allis-Chalmers Manufacturing Company, with its progressive engineering organization and this background of experience, is in a position to serve in any problem of power generation and application while its products reach into practically all branches of engineering.



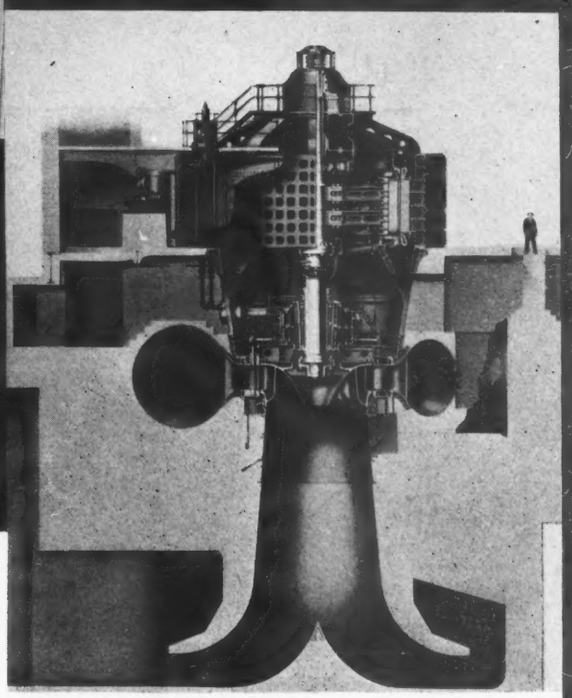
EARLY WATER WHEEL—From a pamphlet printed in 1865.

44 EDWARD P. ALLIS & CO'S
WATER WHEEL.
L. D. GOODWIN'S PATENT CENTRAL DISCHARGE WATER WHEEL.—With Wood Scroll.
The above and following cuts are representations in part of L. D. Goodwin's Patent Direct Acting and Combination Water Wheel, patented April 4, 1859, of which we are sole manufacturers for the West.

"ALLIS" EQUIPMENT—From a wood cut of 50 years ago.



STEAM TURBINE-GENERATOR INSTALLATION—Installation of large units. Beginning in 1922 units rated 25,000-kw, 35,000-kw, 50,000-kw, 65,000-kw and 115,000-kw installed in the same plant.



HYDRAULIC TURBINE 70,000-hp, 65,000-kva, 107-rpm, 213-ft. head; installed in 1922, at Niagara Falls. This turbine developed 83,000-hp in plant.

Significant Dates in Allis-Chalmers History

1847—Company formed to manufacture mill stones in Milwaukee; later became the Edward P. Allis Company.

1862—Approximate date of first Allis water-wheel, built under Goodwin's patent.

1868—Edward P. Allis & Co. (Predecessor of Allis-Chalmers) built its first steam engine, 100-hp for a flour mill.

1875—First Steam Driven Vertical Reciprocating Pumping Engine.

1878—The Reynolds Corliss Engine offered to the public. In the following seven years over 500 engines were built averaging 24" x 48" in size.

1881—First High Economy Blowing Engines—employing metal valves where leather had previously been used.

1884—First Centrifugal Pump. (48" x 72", for handling sewage).

1886—The first Vertical Triple Expansion Pumping Engine built for water works service in any country. Outstanding record for economy. (Still in service.)

1888—Built world's first Large Screw Pump (500,000,000 gallons per day) for handling a large volume of water at low head. (Still in service).

1892—First Steam Engines in America for direct-connection to generators (500-hp).

1901—Organization of Allis-Chalmers Company, through consolidation of The Edward P. Allis Company, Fraser & Chalmers Company, Gates Iron Works, and the Dickson Manufacturing Company.

1901—Built first "Manhattan Type" Angle Compound Corliss Engines, (see previous page). World's record for size. (Still in service).

1904—Acquired the Bullock Electric Mfg. Co., a leading manufacturer of electrical machinery since 1888.

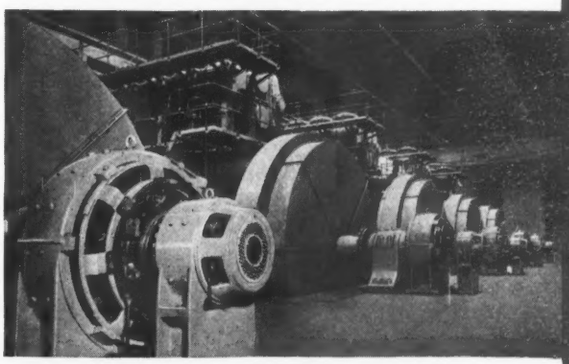
1904—Built first Steam Turbine Unit, 5,500-kw.

1904—Actively entered Hydraulic Turbine field. To date many outstanding records have been established. World's records at Niagara Falls are significant: In 1919 37,500-hp unit (including generator) installed and followed in 1922 by 70,000-hp unit. 1934, four 115,000-hp turbines under contract for Boulder Canyon Project.

1908—World's Record Gas Engine Installation—17—2,000-kw gas engine generator units, with 8 similar blowing engines, operating on blast furnace gas. Followed by other installations making a total of 110 engines in three plants. Latest installations include six 6,000 and three 10,000-hp units with generators.

1922—Entered the field of large Steam Turbine Generator Units. Units from 20,000-kw up to 125,000-kw have been built or are under contract.

Six 6 000-hp and two 10,000-hp Allis-Chalmers Gas Engine Generator Units in a steel mill power plant.



Five 7 500-kva Allis-Chalmers Generators and exciters direct-connected to Diesel Engines, City of Vernon, California. Largest Diesel Electric Installation in America.

Products of Allis-Chalmers

ELECTRICAL MACHINERY
- Motors, Generators
- Switchgear, Transformers
- Mercury Arc Power Rectifiers
- Railway Electrification Equipment
- Generator Voltage Regulators

STEAM TURBINES

STEAM, GAS AND OIL ENGINES

CONDENSERS

HYDRAULIC TURBINES

PUMPING ENGINES

CENTRIFUGAL PUMPS

BLOWERS AND COMPRESSORS

MINING AND METALLURGICAL MACHINERY

CRUSHING AND GRINDING MACHINERY

CEMENT MAKING MACHINERY

FLOUR AND CEREAL MILL MACHINERY

SAW MILL MACHINERY

ELECTRIC MINE HOISTS

TEXROPE DRIVES - TRANSMISSION MACHINERY

TIMBER PRESERVING MACHINERY

COAL DISTILLATION MACHINERY

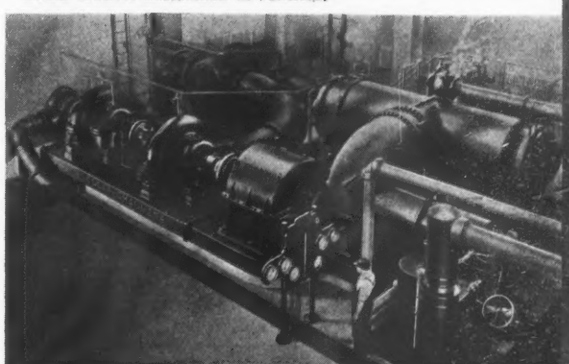
FORGINGS AND PLATE WORK

TUNNEL SHOVELS

FARM, INDUSTRIAL AND TRACK-TYPE TRACTORS

TILLAGE, PLANTING AND HARVESTING MACHINERY

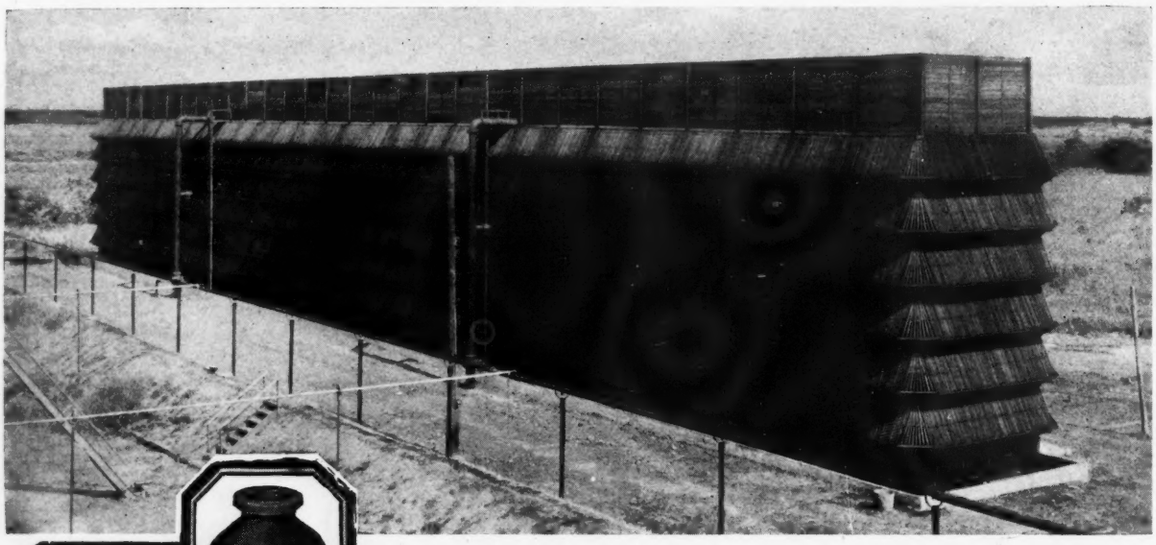
ROAD MACHINERY

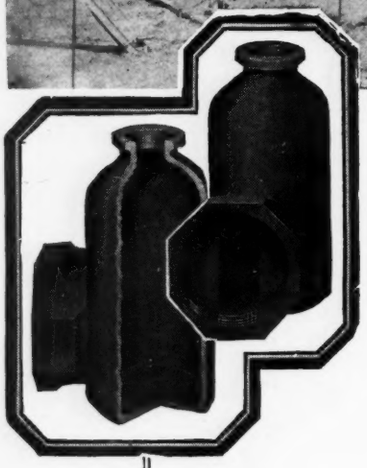


Steam Turbine driven Centrifugal Pumping Unit rated 60 million gallons per day against 300-ft. head, condenser and circulating water pump.

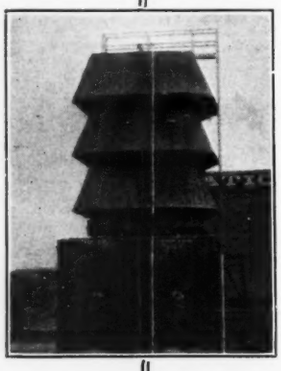
ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee





Consistently Prov in Design and



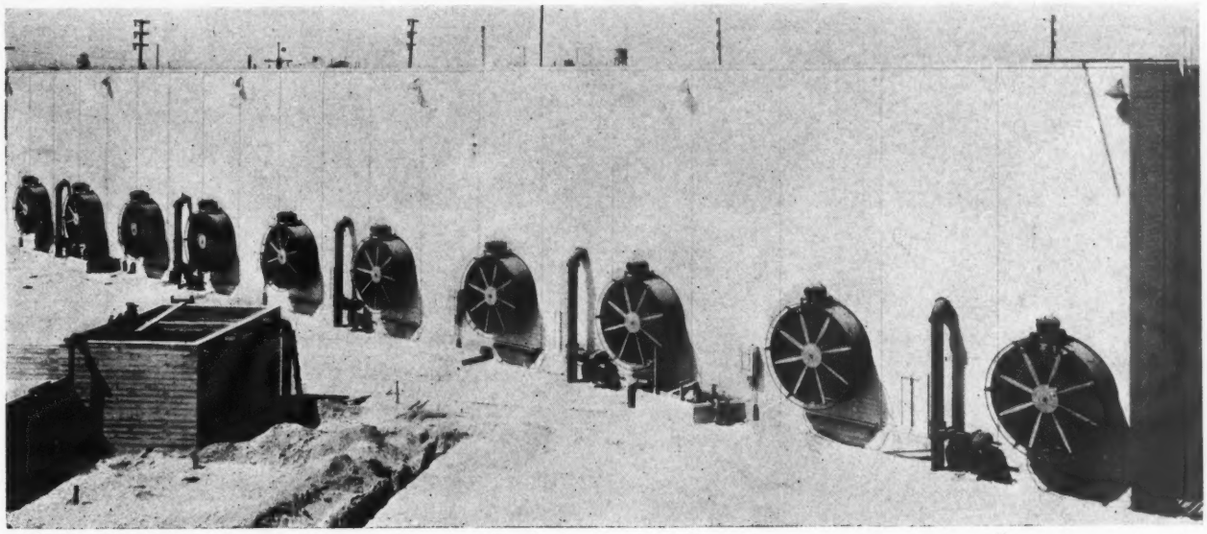
The efficiency of any cooling system is in direct proportion to the soundness of its design.

That is why Marley cooling systems have been consistently proved and improved—why they now possess patented and other advantages found in no other makes—why today's Marley cooling systems admittedly set new standards of design and performance for the cooling industry.

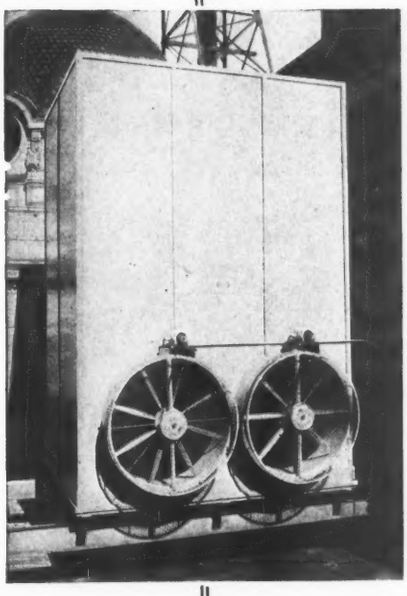
Let Us Spray MARLEY COOLING EQUIPMENT "THE BETTER WAY"

THE MARLEY COMPANY

Kansas City **Missouri**

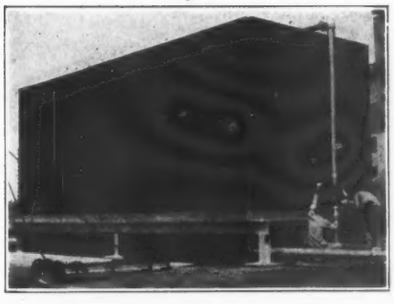


ed and Improved Performance

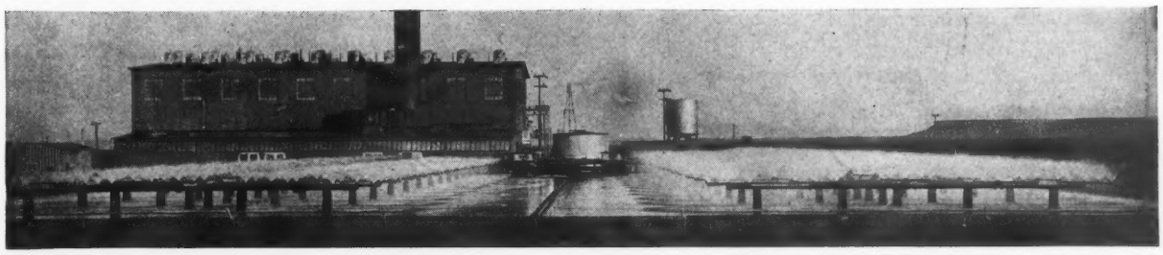


The Marley patented spray nozzle for all cooling systems, the Marley patented Louvred-louvre for deck towers, Marley spray distribution and Multi-Blade fans for forced draft towers—all are specific, effective Marley improvements that increase cooling efficiency.

Marley manufactures spray nozzles, spray ponds, spray towers, forced draft towers, atmospheric deck towers and all accessories. Write for descriptive literature.



MARLEY
COOLING SYSTEMS



Not New "BUT Different

In order for a product to win almost instantaneous popular acceptance it must be different in the right way—it must perform an unusual service—fill a long-felt want —correct the abuses of past methods. Also it must prove itself. FIRITE Stokers have explored the proving grounds of a national market—met the most exacting demands of large steam users.

What improvements would you make on your present equipment if you were building a stoker yourself?

You would want to be able to burn any kind of coal, to get higher ratings, and to get higher operating efficiencies.

You would want to be sure that there would be no clinker formations regardless of special fuel characteristics, such as high sulphur or low ash fusion temperature.

You would probably like to operate less boilers and have a higher standby factor.

You would wish to be relieved from expensive fire brick bills and have lower stoker maintenance and get away from frequent boiler outage for stoker and furnace repairs.

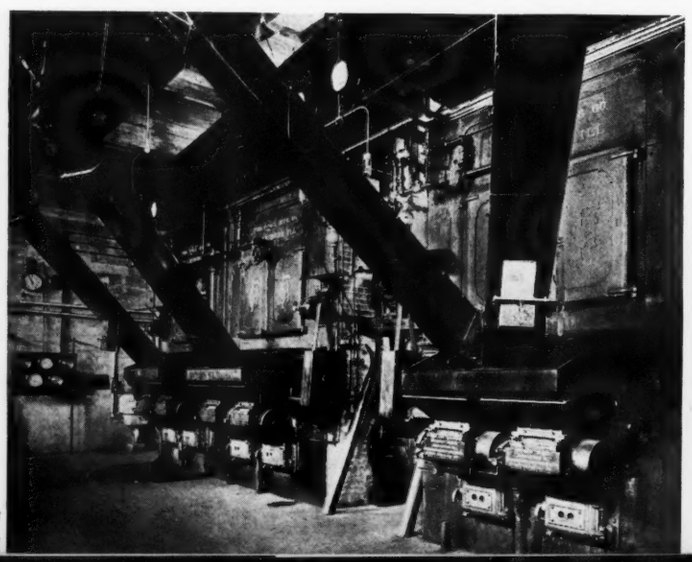
You would wish to reduce your banking losses, and to reduce boiler tube replacements.

You would like to obtain higher CO_2—lower ash pit losses—lower stack temperatures, and you would like to handle less coal and ash.

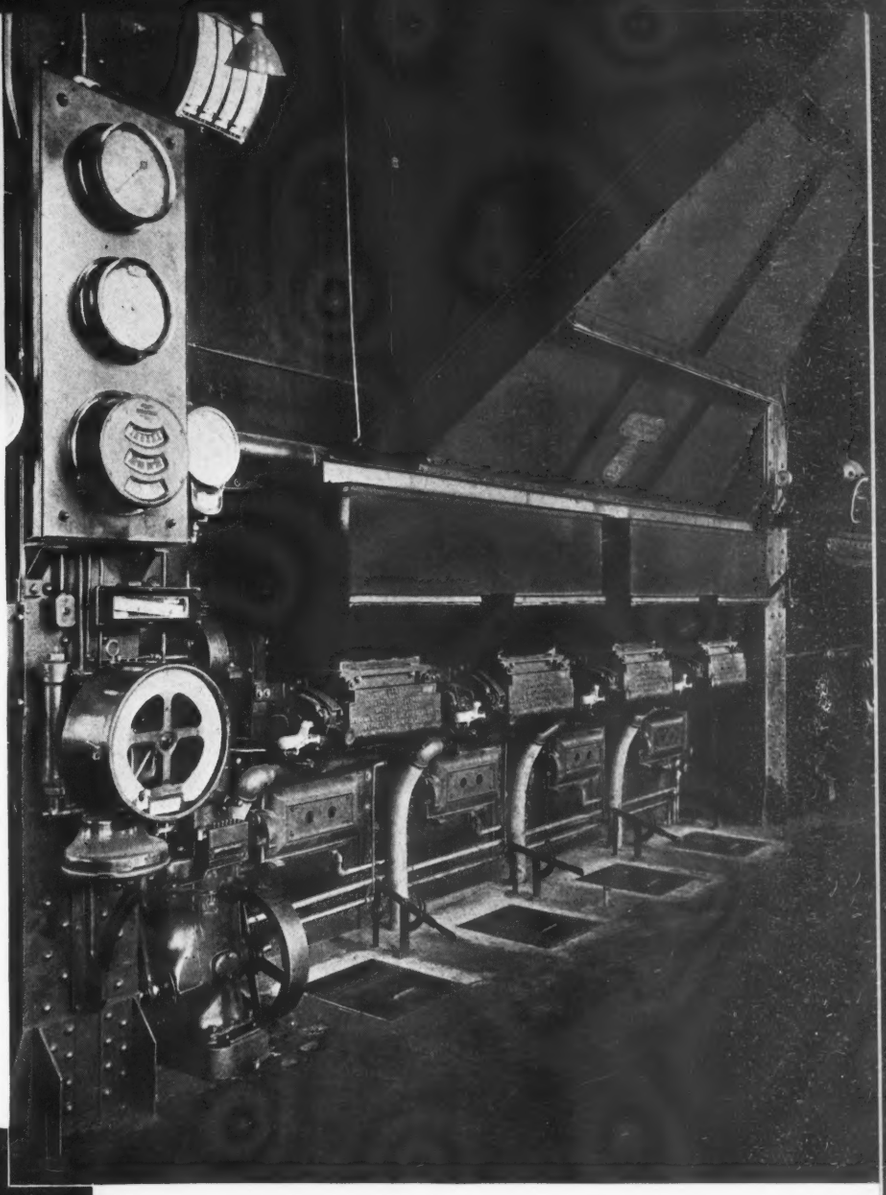
In short, if you had a stoker with all of the above qualifications you would be 100% satisfied. Well, there are hundreds of people all over these United States who are 100% satisfied with their FIRITE Stokers, because this modern fuel burning equipment accomplishes all of the things you have wanted, but thought you couldn't have. Have you considered heavy stoker maintenance a necessary evil? It might have been the case once; but it is no longer true.

FIRITE Stokers are built in sizes from 100 to 1200 horsepower, and to produce steam in quantities from 3000 to in excess of 100,000 pounds per hour. The cost of steam is a major factor in many industries and institutions, such as paper mills, dairies, dye houses, laundries, and many other important industries and institutions.

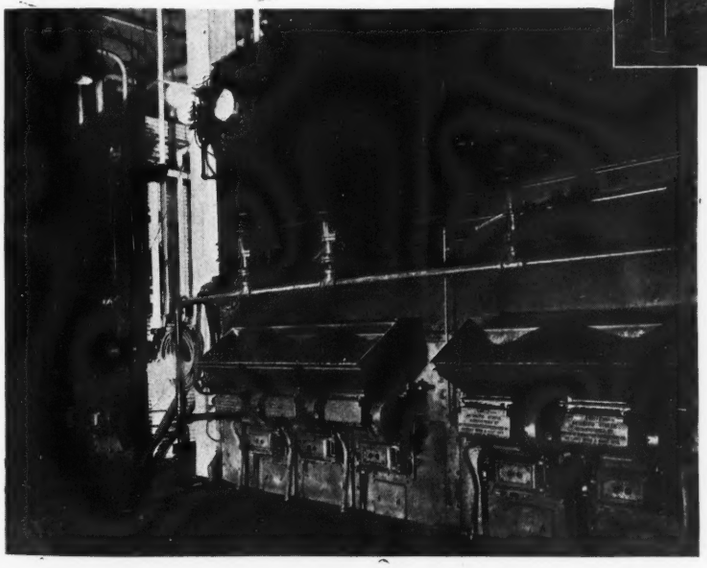
What steps are you taking to keep your steam costs, maintenance, etc., in line with modern practice? There is no reason in the light of present engineering developments why medium sized industrial and institutional boiler plants cannot be operated at efficiencies to approximate central station standards.



3 *typical* "FIRITE" *installations*



A national organization of experienced fuel and steam survey engineers is at your disposal. Why not take advantage of this service and obtain some accurate information as to whether your present coal burning equipment is obsolete, and find out what potential economies exist? This practical engineering service is a part of our stoker merchandising program, and of course there is no obligation.



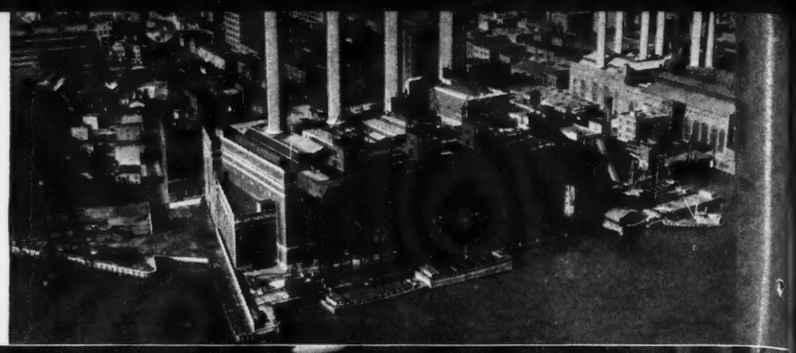
HOFFMAN COMBUSTION ENGINEERING COMPANY

Ford Building **Detroit, Mich.**

Branches in Principal Cities

Firite STOKERS

WORLD'S LARGEST INSTALLATION OF DRAFT FANS!

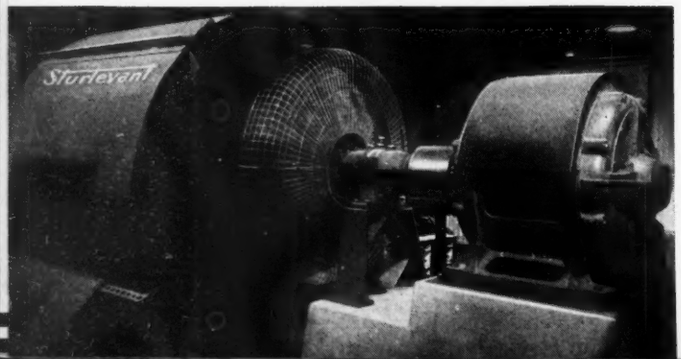


Sturtevant
REG. U.S. PAT. OFF.

22 MILLION POUNDS OF GAS AND AIR PER HOUR

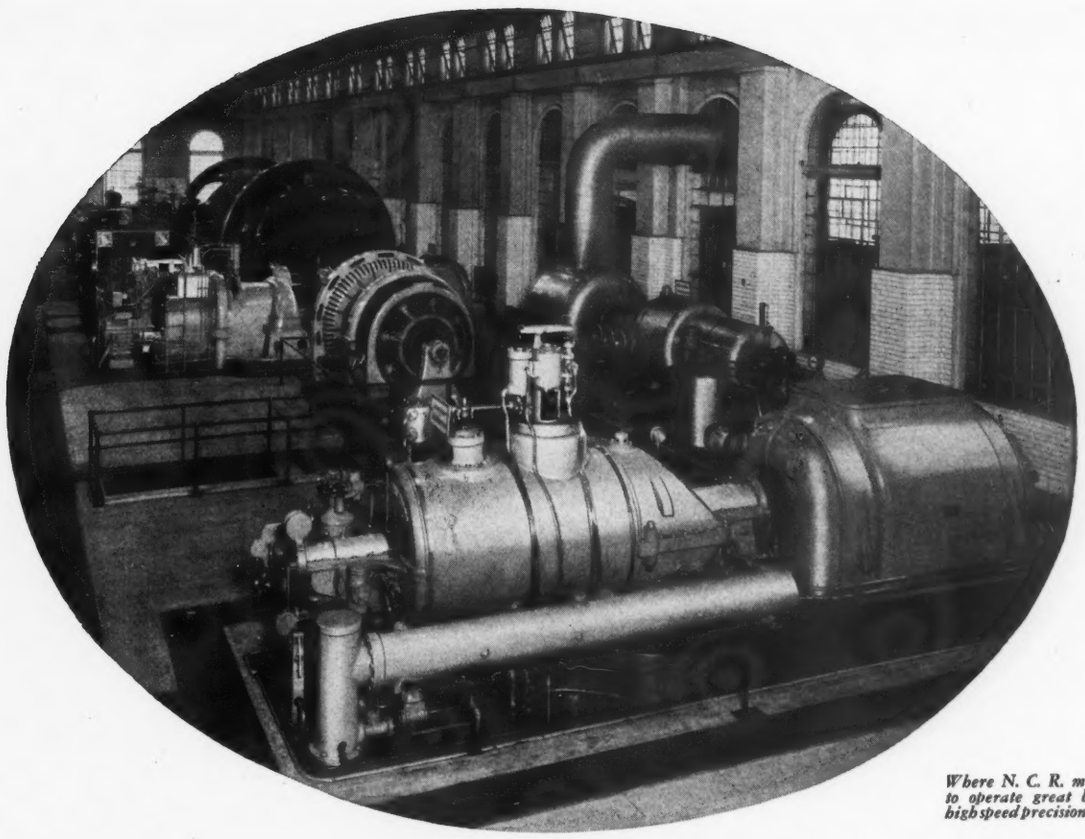
...combined capacity of Sturtevant Draft Fans at Hudson Ave. Station, Brooklyn Edison Co.

There are 47 Sturtevant Vane Controlled Fans in this power plant. Combined motor rating...28,/00 horsepower! They constitute the largest installation of mechanical draft fans in the world. ¶ After most searching investigation and study the engineers of the Brooklyn Edison Company selected these fans on the basis of proved efficiency and mechanical construction. B. F. Sturtevant Company, Hyde Park, Boston, Mass.



★

Main illustration above: Battery of Sturtevant Induced Draft Fans, a few of the 47 Sturtevant Fans at Hudson Ave. Station, Brooklyn Edison Company. *At left:* One of the Sturtevant Forced Draft Fans at the same station.



Where N. C. R. makes power to operate great batteries of high speed precision machinery

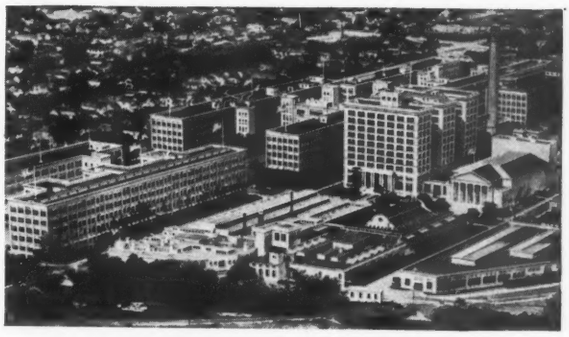
NATIONAL CASH REGISTER RINGS UP MAINTENANCE AND POWER SAVINGS!

Cuts Operating Costs with Gulf Quality Lubrication

. . . AND SO CAN YOU!

YOUR power plant, like that of the National Cash Register Co., can be operated more efficiently and economically with Gulf lubricants.

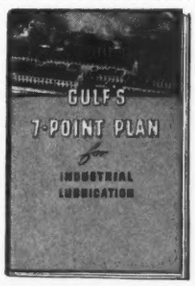
Gulf's *complete* line of industrial lubricants and Gulf engineering service can help you make the maintenance and operating savings you need to meet today's conditions.



Aerial view of the National Cash Register Company's world famous plant at Dayton, Ohio

GULF REFINING COMPANY
PITTSBURGH, PA.
District Sales Offices:
Boston, New York, Philadelphia, Atlanta, New Orleans, Houston, Pittsburgh, Louisville, Toledo

GULF INDUSTRIAL LUBRICATION



GULF REFINING COMPANY P. 6
3800 Gulf Building
Pittsburgh, Pa.

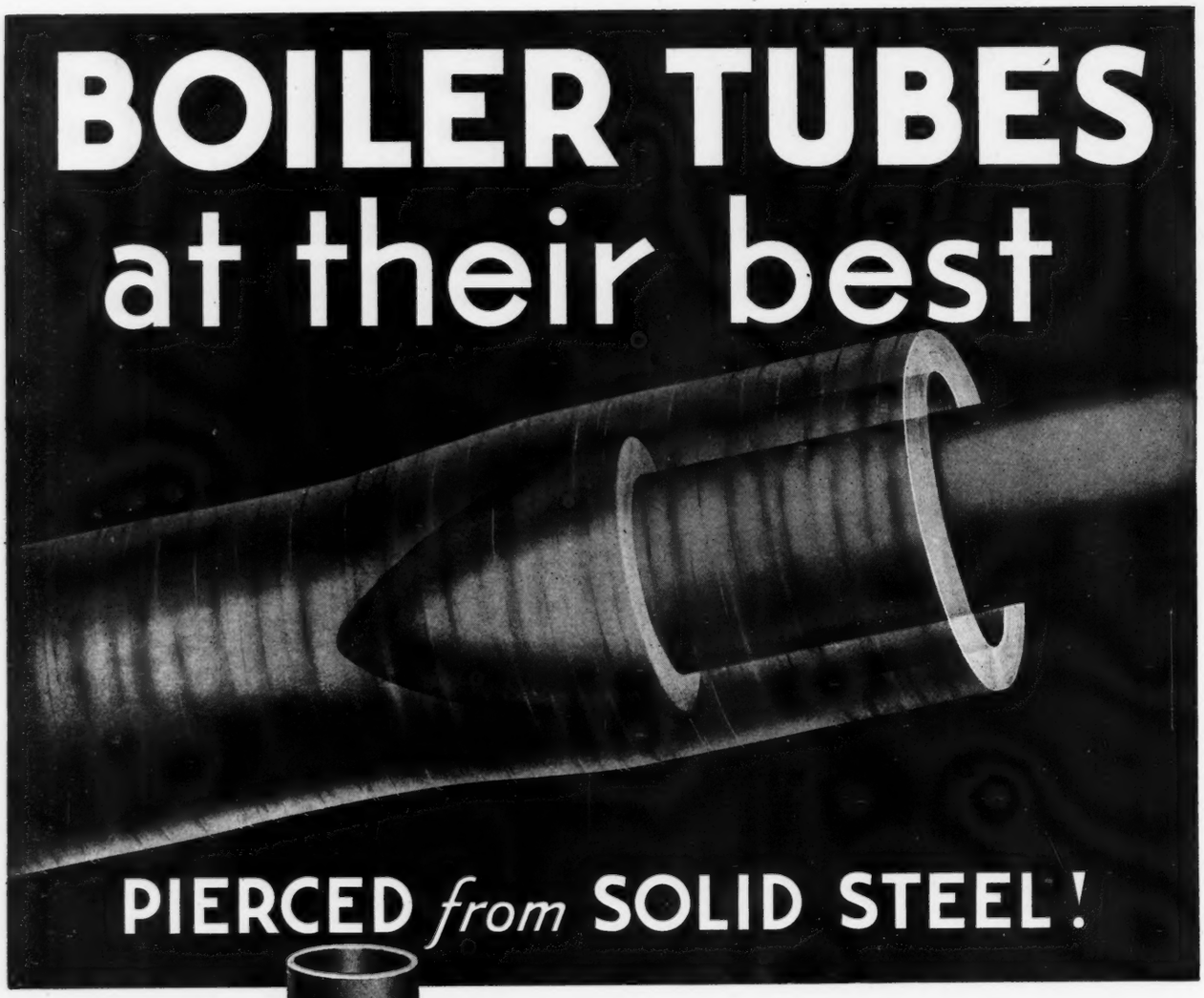
Please send me, without charge, "Gulf's 7 Point Plan for Industrial Lubrication."

Name.....

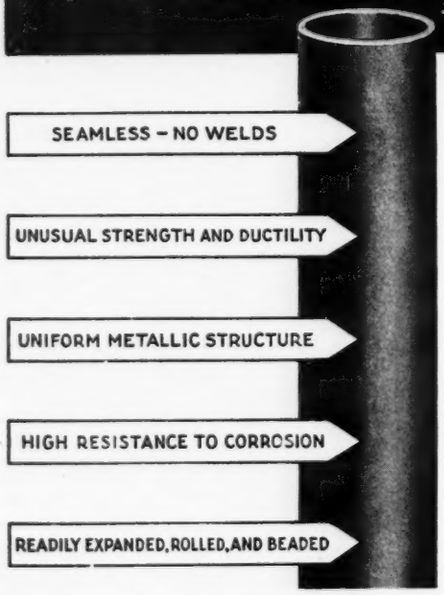
Company.....

Address.....

BOILER TUBES at their best



PIERCED *from* SOLID STEEL!


SEAMLESS – NO WELDS
UNUSUAL STRENGTH AND DUCTILITY
UNIFORM METALLIC STRUCTURE
HIGH RESISTANCE TO CORROSION
READILY EXPANDED, ROLLED, AND BEADED

There is no weld

No weld—no long line of possible weakness. No chance, no dependence on the human element, no uncertainty of any kind need be allowed for, as affecting the uniform wall strength of a NATIONAL Seamless Boiler Tube. One continuous hollow cylinder, pierced from a solid billet, expanded and rolled at proper and definitely controlled temperatures to produce grain refinement and uniform transverse and longitudinal strength A balanced, homogeneous unit—unsurpassed from a manufacturing standpoint.

Likewise, from a service standpoint NATIONAL Seamless Boiler Tubes represent the ultimate of security. In countless railway, marine, and stationary boiler installations, they have proved reliable in every way under the most trying conditions. To get the advantage of the highest quality seamless boiler tubes, specify NATIONAL-SHELBY—

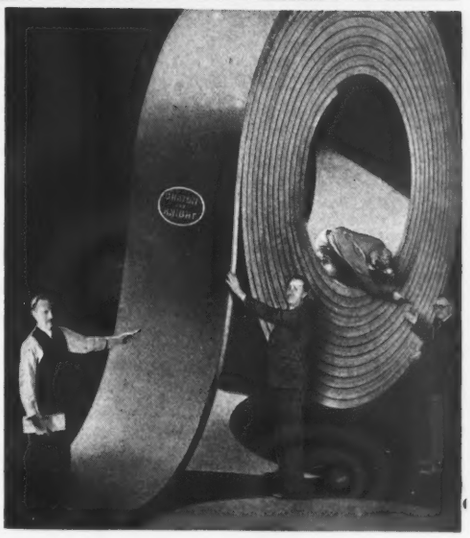
America's Preferred Boiler Tubes

NATIONAL TUBE COMPANY · Pittsburgh, Pa.
Subsidiary of United States Steel Corporation

NATIONAL SEAMLESS

BOILER TUBES—SAFE ENDS—SUPERHEATER TUBES—CONDENSER TUBING—ARCH TUBES—SUPERHEATER PIPES—STAY-BOLT MATERIAL

From plant after plant comes the verdict . . .
"THIS IS THE FINEST BELT WE HAVE EVER USED"



GRATON AND KNIGHT

Good flat leather belting, properly installed and cared for, has always been one of the most efficient forms of power transmission. This fact, plus the low initial cost of this type of machine drive gives it a tremendous advantage over all others.

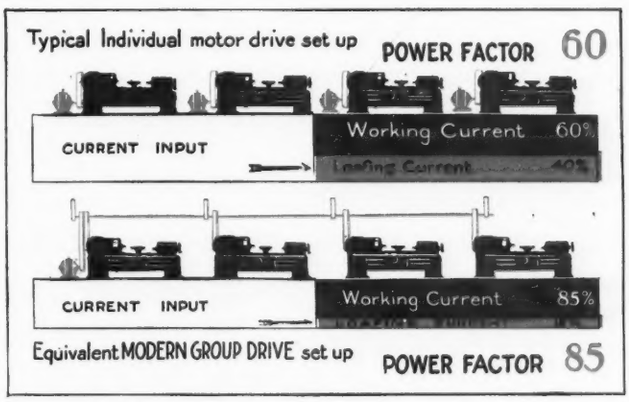
Now that Graton & Knight Research Belting has so greatly bettered the performance and economy of modern group drives as well as individual machine drives, its installation is a major factor in profitable plant modernization.

Not only does Research Flat Leather Belting run with little or no stretch, but because of its greater flexibility and new high friction surface, it pulls full loads without slip, without "breaking in" and with only normal tension and bearing pressures.

"This is the finest belt we have ever used," say hundreds of New Research Belt users. Performance facts support their statements. Our local power transmission man has carefully recorded operating data showing just what Research Belts are doing in your industry and others. He can show you immediate and worthwhile savings on a very small investment. Write Graton & Knight Company, Worcester, Mass.

HIGHLIGHTS of the MODERN GROUP DRIVE No. 4

How much loafing current on your payroll?



Indiscriminate use of individual motor drives is directly responsible for power factor troubles. Not only is the power factor for small induction motors normally lower than for larger units of the same type, but the motors on practically all individually driven machines operate underloaded, still further aggravating power factor troubles.

Modern Group Drive offers a logical solution to the problem of poor power factor without recourse to costly corrective equipment.

This chart is taken from a booklet published by the Mechanical Power Engineering Associates, and giving in non-technical form the results of a two-year study of the place and comparative economy of modern group and unit drive systems in Industry. We will be glad to send you a copy on request.

PERFORMANCE FACTS *tell why!*

Research belting, installed as a test on one of the 15 hp. fan drives in a series of cooling towers, proved so satisfactory that the other drives were at once similarly equipped. None of the belts has yet been shortened *after from two to three months continuous operation.*

After *a year and a half* of continuous operation on a short center 15 hp. vacuum pump drive, a 5" Research Belt in a tire company's plant shows only 2" stretch. Previous belt life on this installation was *from 2½ to 3 months.*

In a Philadelphia paper mill, the 28" Research belt on the turbine drive to a paper machine was shortened only 4" (.06%) about a week after installation. At the end of three months continuous operation this belt showed no further stretch. Horsepower of turbine, 260 with 25% overload capacity. Driving pulley 26"x30" face; driven pulley 33"x30" face; centers 23'1", 40° angle, tight side on bottom. Turbine speed 176 to 716 r.p.m.

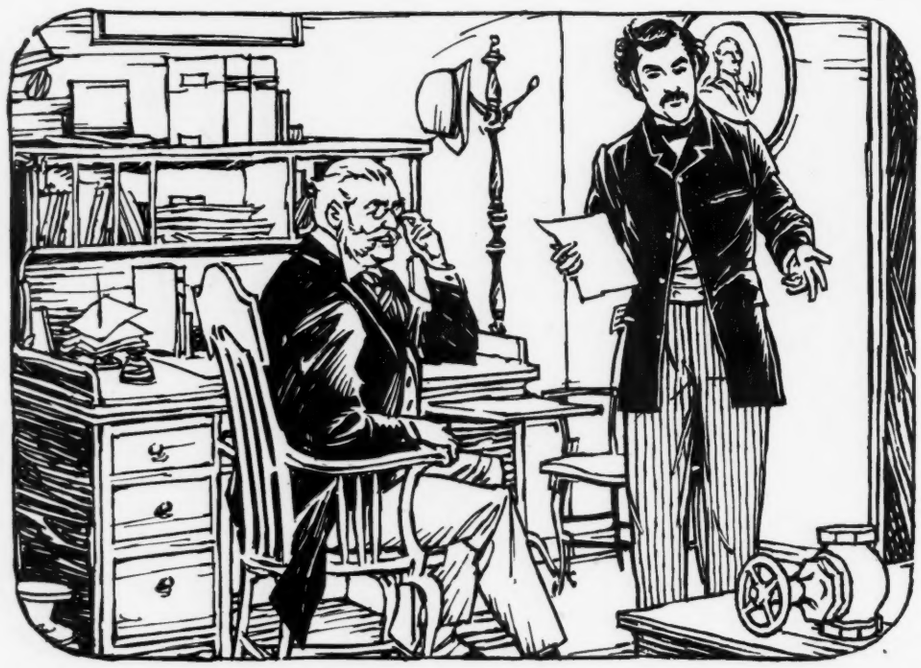
A St. Louis shoe company has some interesting Research belted, fixed, short center blower drives, which have been in operation over two years with highly satisfactory results. Centers are 20", the belts 3" singles driving vertically from 3 hp. motors 1750 r.p.m. with 4" driving pulleys and 12" blower pulleys. What little stretch has taken place has been easily compensated for by adjustment of the motors without removing the belts.

NRA

GRATON & KNIGHT *Research* LEATHER BELTING

GRATON & KNIGHT COMPANY . . . . . WORCESTER, MASS

We Sold Them IN 1869



WHEN they were building the Central State Hospital, Indianapolis, in 1869, we sold them Jenkins Valves for the heating system.

We have just learned that these valves have been in constant use, and are still giving a good account of themselves.

To serve so satisfactorily through all of those years, these valves must have in them a quality that cannot be measured by scales or calipers. They must possess that inherent, if indefinable, merit that is found only in those products that have built into them the honor and pride of the skilled craftsman. It is this high standard of skilled workmanship that has been the heritage and unvarying policy of Jenkins Bros. for 70 years. It has earned for Jenkins Valves the favorable opinion of engineers the world over. It is this that makes the use of Jenkins Valves a very real economy

In every detail of design and construction, Jenkins Iron Body Gate Valves portray an exceptional fitness for long, hard service, with a minimum of attention. Write us, or ask your supply house for a large cut-out model and compare with other valves. Jenkins Iron Body Gates are made in sizes to 48 inches with Solid Wedge or Double Disc Parallel Seat.

Jenkins Bros

JENKINS BROS., 80 White Street, New York, N. Y. 510 Main Street, Bridgeport, Conn.; 524 Atlantic Avenue, Boston, Mass.; 133 N. Seventh Street, Philadelphia, Pa.; 822 Washington Boulevard, Chicago, Illinois; JENKINS BROS., Limited, Montreal, Canada; London, England

JENKINS VALVES · SINCE 1864 · BRONZE · IRON · STEEL

At the largest distillery of its kind in the world

Just completed for Hiram Walker & Sons, Inc., at Peoria, Illinois. Smith, Hinchman and Grylls, Architects and Engineers, Detroit, Mich.

1. Construction picture showing conveyor gallery from crushing station to bunkers in power house.

2. Reciprocating Feeder under track hopper. Capacity 75 tons per hour, run-of-mine coal.

3. 30-in. belt conveyor with magnetic head pulley feeding coal to crushers.

ROBINS CONVEYING EQUIPMENT

handles Coal, Ashes, Meal and Dried Grain

The coal drawn by a Robins Reciprocating Feeder (Fig. 2) from the track hopper to a 30″ Robins Belt Conveyor with magnetic head pulley (Fig. 3) is delivered to a Robins double-roll crusher or by-passed around the crusher if already sized.

Crushed coal is elevated by another Robins Belt Conveyor (Fig. 1) and distributed by tripper to a 3,000-ton bunker.

Under the bunker gates three Robins Power-Controlled Larry Cars deliver coal to three automatic scales which weigh and record all coal delivered to the pulverizers.

Ashes are removed automatically by a Robins Combination Chain and Cast Iron Flight Drag Conveyor operating under water in a cast iron trough and discharged to trucks or cars by a new type of shuttle of similar design.

Ground meals are automatically weighed and automatically delivered to the cookers, either as dry or wet meal, by a system entirely new, which positively controls the formula content to each cooker and eliminates danger of error in manual control.

Dried grains are stored in Robins Bins and conveyed, automatically weighed, and delivered to cars in bulk or in bags.

Robins has an economical solution for any problem of bulk material handling

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MATERIAL HANDLING
ROBINS
EQUIPMENT

Representatives in other principal cities

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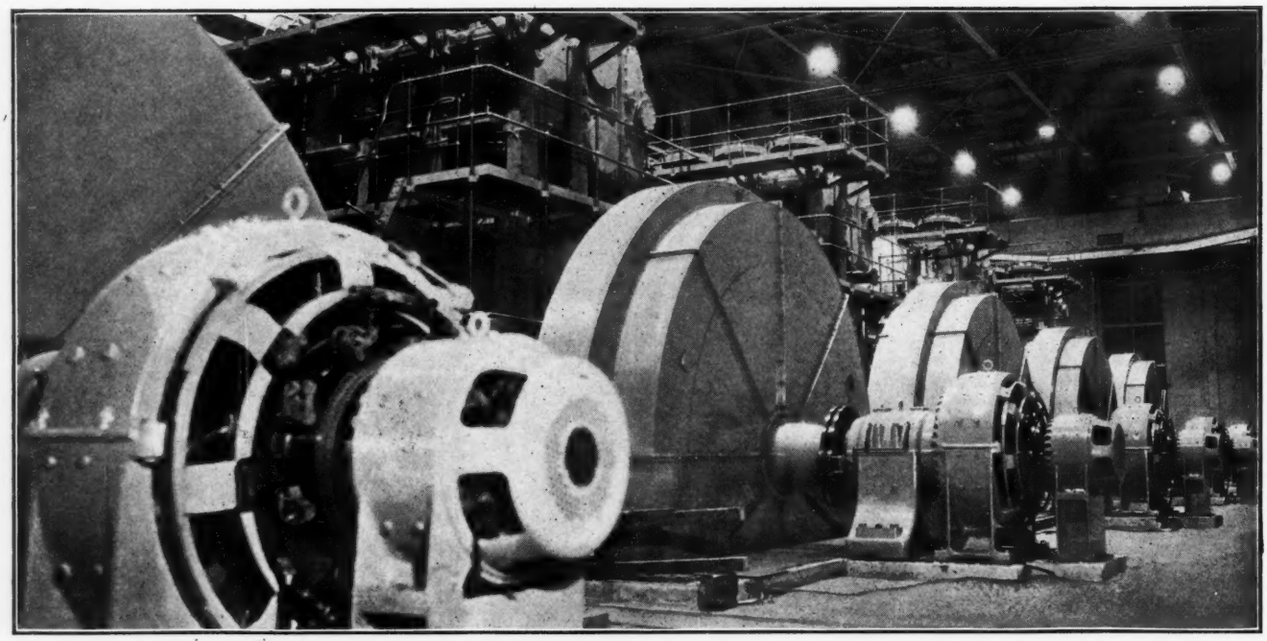
AMERICA'S LARGEST DIESEL PLANT USES AMERICAN HAMMERED PISTON RINGS



Five 7000 B. H. P. Hamilton M. A. N. Diesel Engines at Vernon, California

Hammered tension is uniform tension—tension that is maintained during the entire life of the ring. That's why American Hammered Piston Rings are the choice of a constantly increasing number of America's leading engine builders and engine operators.

AMERICAN HAMMERED PISTON RINGS

IN EVERY SIZE
OF EVERY TYPE
FOR EVERY PURPOSE

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THE AMERICAN HAMMERED PISTON RING CO.

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Street Railway Journal

Vol. XXVII. NEW YORK, SATURDAY, MARCH 24, 1906. No. 12.

1454 POWER AND THE ENGINEER August 16, 1910.

Large Noncondensing Power Pl...

REMEMBER

when 175 lbs. was HIGH PRESSURE

TYPICAL BUSINESS STREET, BIRMINGHAM, ALA.

Warrior River on the northwest. The city of Birmingham ... the franchises under which the company operates its railways ... are other unlimited in ... Birmingham, are subsidiary ... Besides the engine units there are two ... Curtis turbines driving 3000-kilowatt ...

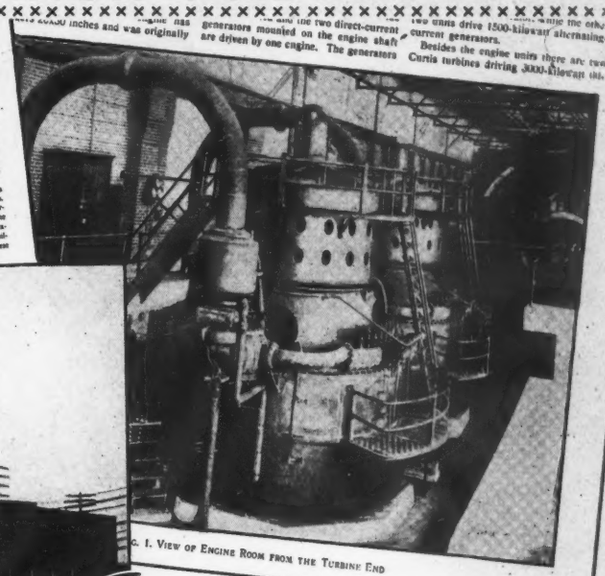
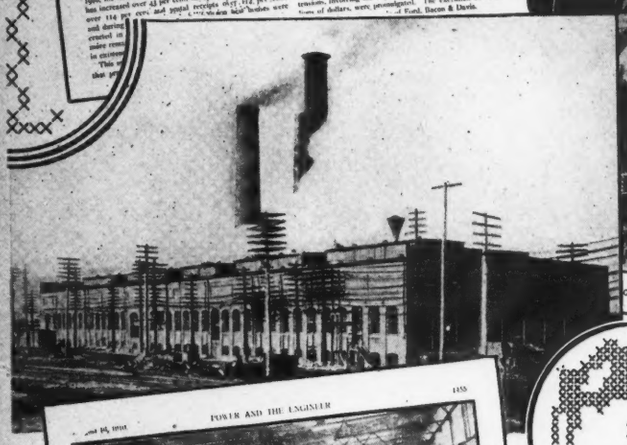


FIG. 1. VIEW OF ENGINE ROOM FROM THE TURBINE END



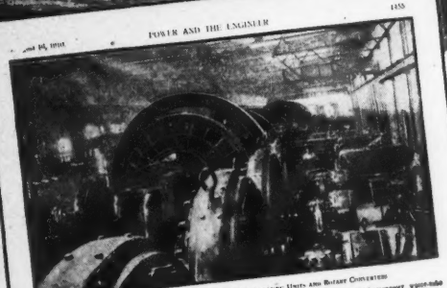


FIG. 2. VIEW OF ENGINE ROOM, SHOWING RECIPROCATING UNITS AND ROTARY CONVERTERS

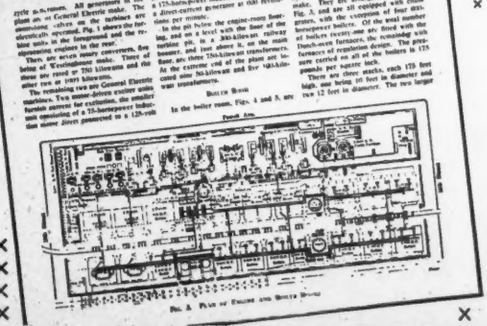


FIG. 3. PLAN OF ENGINE AND BOILER ROOM

In 1901, the Birmingham (Ala.) Railway, Light & Power Company, now Birmingham Light Company, started a "then gigantic" expansion program at their Powell Avenue Station, under the direction of Ford, Bacon & Davis. When completed in 1908, this was probably the largest central station in the United States running both reciprocating engines and turbines noncondensing. ¶ With 31 B. & W. boilers totaling 17,200 h.p., six Corliss engines both double and compound aggregating 9,850 h.p., 2-3000 k.w. Curtis turbines 2-10,000 h.p. Cochrane Feed Water Heaters and 5 Blake Compound Duplex Feed Water Pumps the piping too, was a "then gigantic undertaking." This plant presented many "then new, unique" problems for us at that time, with its "then high pressure of 175 lbs." and its "then unusual" noncondensing operation with exhaust steam used for heating practically the entire city business district. ¶ Since 1890, as new machines and methods have replaced one another in the advancement of steam generation and industrial processes, Shawco has paralleled this development by solving the myriad new, unique, and exacting piping problems. Today, this experience introduces economy, as well as perfection, into all contracts done by Benjamin F. Shaw Co., Wilmington, Delaware. ¶ Book of Installations sent on request.

SHAWCO

POWER & INDUSTRIAL PIPING FABRICATORS & CONTRACTORS

IT is not uncommon for Armstrong traps to perform faultlessly for several years without any repairs or attention other than periodic inspection. It is also common for identical Armstrong traps to be installed under conditions which lead to trouble in a comparatively short time. In both cases the fundamental Armstrong guarantee of "complete satisfaction" applies. In the first case the design and construction of the trap produce satisfaction. In the second case, the Armstrong field organization comes in to complete the job of satisfying the customer. They provide the "human element" so necessary even with the finest mechanical device built. The Armstrong interpretation of "complete satisfaction" is broad and it covers the entire life of the trap. Put this guarantee to the test by accepting our 90 day free trial offer.

Let us send you traps for 90 days FREE TRIAL

ARMSTRONG MACHINE WORKS
812 Maple Street, Three Rivers, Michigan

ARMSTRONG "INVERTED BUCKET" STEAM TRAP

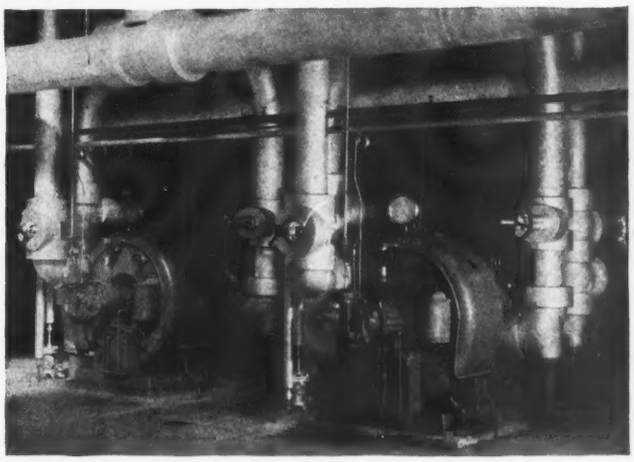
TERRY

8 TERRY SOLID WHEEL TURBINES SERVE ASHTABULA STATION » »

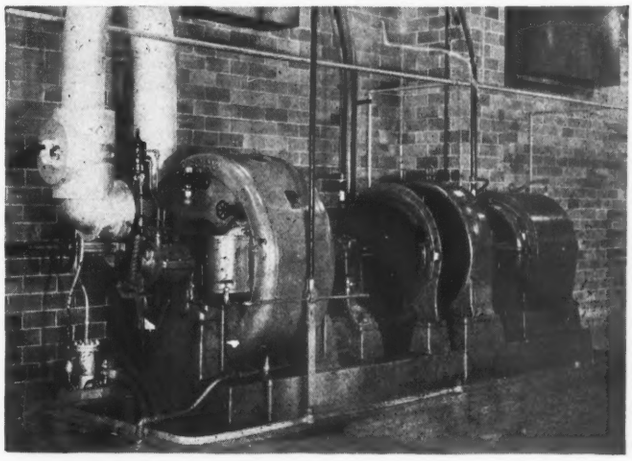
At Ashtabula, the newest station of the Cleveland Electric Illuminating Co., eight Terry turbines are used to drive essential auxiliaries.

These machines employ the solid one-piece Terry turbine wheel. The buckets are milled from the solid metal — not inserted.

The blades have large clearances and are further protected by projecting rims at the sides of the wheel, which would take without damage any rubbing that might occur if clearance became reduced. It is therefore impossible for the blades to foul.



Two 625 HP Terry turbines driving boiler feed pumps



300 KW Terry duplex exciter

Ask for bulletin S-84, which deseribes these durable turbines.

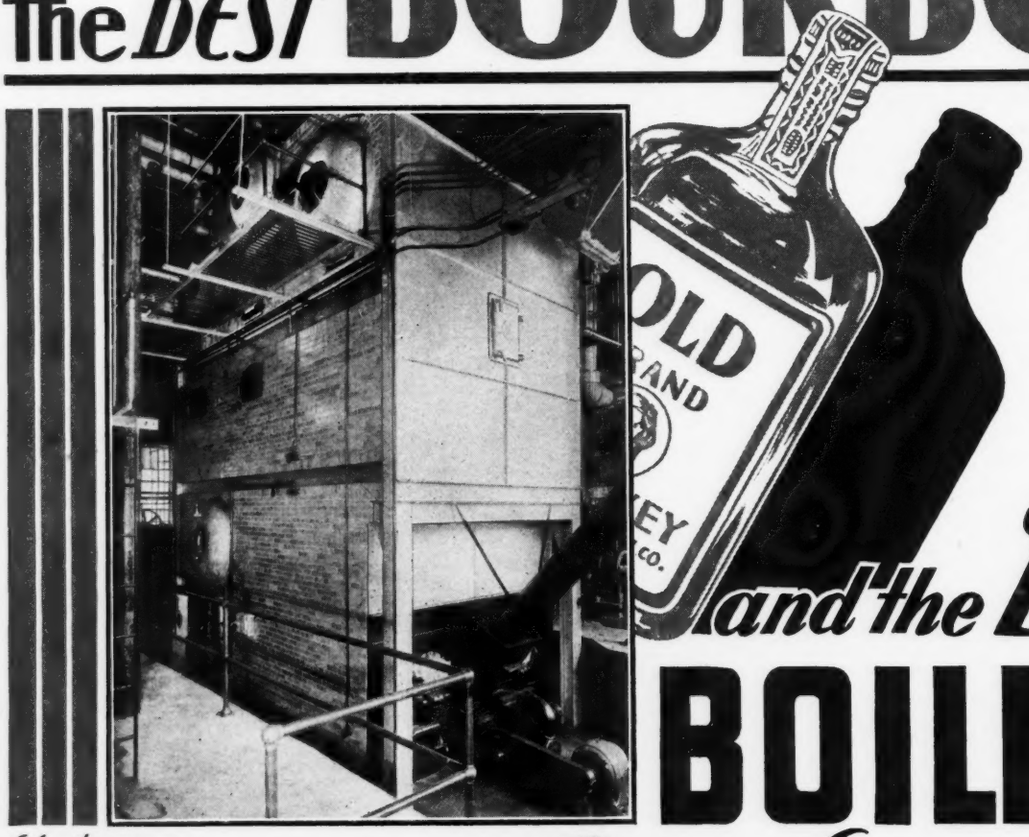
The TERRY Steam Turbine Co.

TERRY SQUARE, · · HARTFORD, CONNECTICUT

TURBINES, GEARS SHAFT COUPLINGS

T-1094

the *Best* BOURBON



and the Best BOILERS

"Made in Ole Kentucky"

BEATEN paths are still made to the doors of quality products, whether they be mouse traps, bourbon or boilers.

It is not difficult to understand why VOGT boilers have had the enthusiastic approval of steam plant operators for half a century. Each unit is correctly designed for the duty to be performed and is fabricated from the best material, with modern shop equipment, by skilled workmen.

Distilleries and breweries or any other industry desiring economical production of steam for power or process are invited to consult Vogt engineers without cost or obligation.

Vogt

WATER TUBE *and* TUBULAR Boilers

Henry Vogt Machine Co., *Incorporated*, Louisville, Ky.

William S. Elliott
Engineer, Pro-phy-lac-tic
Brush Co.

What an Iron Fireman stoker does for Pro-phy-lac-tic Brush Co. it can do for you

● Like many other manufacturers throughout America and in foreign countries, the Pro-phy-lac-tic people have learned that Iron Fireman automatic coal firing is dependable, uniform, and costs far less than any other kind of heating or power which offers anywhere near Iron Fireman's advantages. Mr. William S. Elliott, engineer at the Pro-phy-lac-tic plant, writes:

"A feature which in our work has proved of great value, is the constant pressure which this automatic stoker will maintain. In addition, the Iron Fireman installation allows us to use coal which costs about half the price at the mine as that which we were using previously. This alone has effected a substantial saving in our coal bill. Iron Fireman has given us complete satisfaction in its performance."

Thousands of Iron Fireman stokers on heating and power jobs have written off their cost through savings long ago. A recent estimate showed that fuel cost savings of Iron Fireman users totals well over $7,500,000 annually. Smoke elimination, reduced firing room labor costs, and increased plant efficiency due to steady steam production are further advantages that make Iron Fireman an outstanding investment in power plant equipment.

•

See the Iron Fireman exhibit at the Home Planning Hall, Century of Progress, Chicago.

Iron Fireman heavy duty stoker in the boiler room of the Pro-phy-lac-tic Brush Company plant. Installed in 1930 in a 185 h. p. D. M. Dillon H.R.T. boiler, 100 pounds pressure. Installation by Iron Fireman Sales Co., Springfield, Mass., Iron Fireman authorized dealer.

Plant of the Pro-phy-lac-tic Brush Co.
Florence, Mass.

FREE SURVEY SERVICE

Iron Fireman heavy duty stokers are designed and built for continuous service in power boilers up to 300 h. p. You owe it to yourself to find out what Iron Fireman firing can save in your plant. Just ask for a free survey and report. No cost or obligation. Iron Fireman can be quickly installed and may be purchased on monthly payments. Iron Fireman Manufacturing Co., Portland, Oregon, Cleveland, Toronto. Dealers everywhere.

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AUTOMATIC *Self Regulating* COAL FIRING

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IN BUSINESS 20 YEARS

prolongs life of valves with HAYNES STELLITE

The Haynes Stelliting of valve disks is a simple hard-facing application.

NRA MEMBER U.S. WE DO OUR PART

HAYNES STELLITE was specified by the U. S. Navy for hard-facing the disks of steam globe valves for installation in the new cruisers and destroyers.

Industrial plants everywhere handling high pressure, high temperature steam, gas and oil are now using valves with Haynes Stellite trim, because this cobalt-chromium-tungsten alloy has been found to remain wear resistant even at high temperatures.

Haynes Stellite Engineers will be glad to explain this application in detail. A new booklet, *"494 ways to save money by hard-facing with Haynes Stellite Products"* is available on request.

HAYNES STELLITE

A red-hard, wear-resisting alloy of Cobalt, Chromium and Tungsten.

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Haynes Stellite Welding Rods and information on other Haynes Stellite Products also are available through the 42 apparatus shipping points of The Linde Air Products Company

means Best Lubrication in any man's language!

WHEN you have read the three paragraphs at the right and know the fundamental difference between Pure Oil's "3-Point Service" and other lubrication propositions—you will do what so many hundred others have done; you will send for a Pure Oil man.

Until you do that you may never know how very much better things can be with Pure Oil greases and oils, and how much money you can save on lubrication alone. Processes are smoothed out, spoilage stopped, out-of-service hours cut, repairs slashed, production "upped," costs reduced, when right lubrication replaces wrong. . . . Send for a Pure Oil man.

"3-POINT SERVICE"— YOU LOSE, WITH LESS

(1) The right kind of CRUDE is important. Some types are better adapted to certain uses than others. Pure Oil Crude comes from many fields in nine states, not from a single area producing only *one* kind of Crude that must be recommended and sold for *every* lubrication need.

(2) Good REFINING is vital. No commercially practical refining process can add missing properties to inferior crudes. But even the best Crude must be correctly Refined to prevent loss of inherent lubricating values. Pure Oil modern Refining methods preserve and *improve* the lubricating qualities of Pure Oil superior Crudes.

(3) Scientific APPLICATION is equally important. Good Crude and good Refining go for naught unless skilled engineering selects the best types of lubricant for the particular job in question. Pure Oil Engineers are not only lubrication experts, they have had extensive experience in practical plant operation problems.

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ESSENTIAL TO LIFE
AFFORDS CLEANLINESS
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PROTECT THE WATER SUPPLY AGAINST POWER FAILURE

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At Racine, Wisconsin, one low head 900 R. P. M. and 2 high head 1200 R. P. M. Worthington Centrifugals, driven by direct connected Sterling Dolphin 8 cylinder engines, 240 H. P. at 1200 R. P. M.

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A few hours running on the summer peak load often saves materially in the power costs.

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This is the same test that the U. S. Government Engineering Laboratory performs on oils before approving them for use on battleships, submarines, Navy airplanes, tractors, trucks, cars, machine tools, Army tanks, etc. Let us put your name on our mailing list. WORK-FACTOR NEWS will come to you regularly throughout the year without any obligation whatsoever on your part. Just fill out and mail the coupon below.

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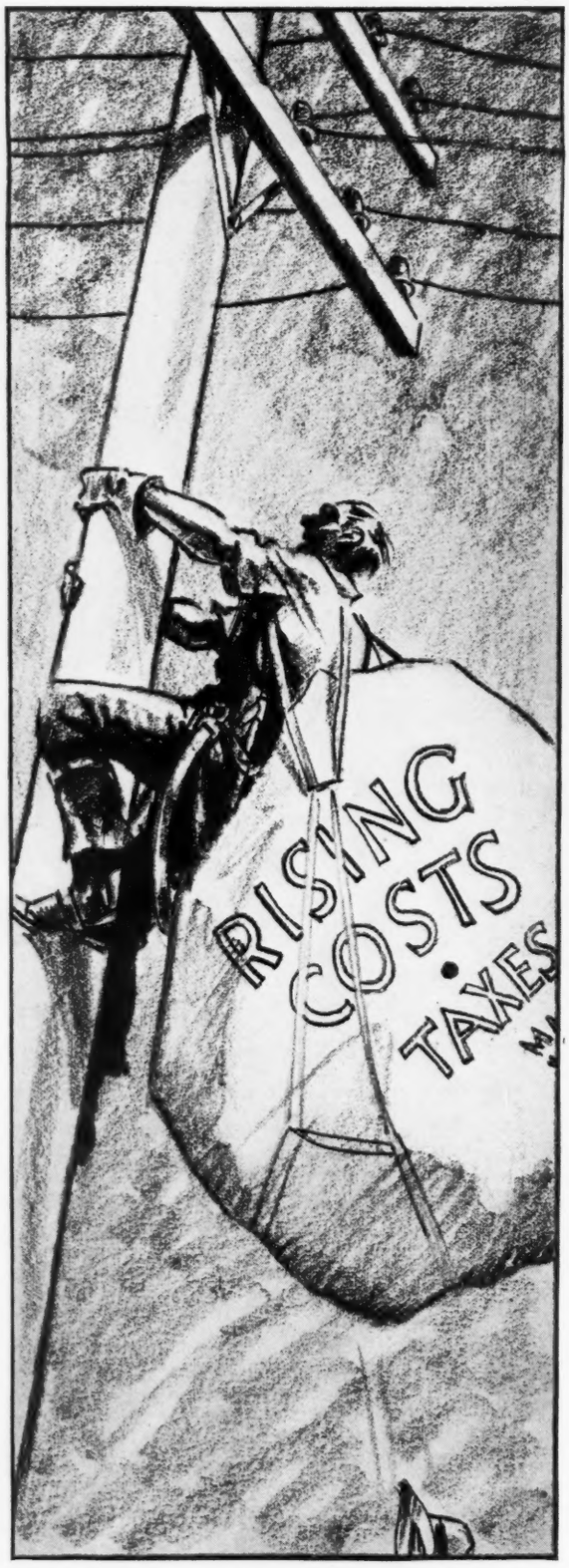

LIGHTEN THE BURDEN

. . . lest the service suffer!

IT is not only the electric industry, its investors and personnel, that are threatened by the burden of mounting taxes, rising costs and concurrent action to force continuously lowered rates.

The ultimate sufferer necessarily will be the Electric Company's *capacity to serve* and its ability to maintain the high standard of service which the public rightly has learned to expect.

It should be the self-imposed duty of each company, locally, to present the facts to its customers; to make certain, as far as possible, that they are given the opportunity to exercise their intelligent choice in a matter that so vitally concerns the welfare of their homes, their industries, and the communities in which they live.

THE NEW YORK EDISON COMPANY · BROOKLYN EDISON COMPANY, INC.

THE UNITED ELECTRIC LIGHT AND POWER COMPANY · NEW YORK AND QUEENS ELECTRIC LIGHT AND POWER COMPANY

MAIN DRIVES *take*

Condor Compensated

PAT. APPLIED FOR

THE LOW TENSION RUBBER BELT

Above is a typical main drive installation belted with a 28-inch, 9-ply Condor Compensated Belt. For very severe drives, an increase in the number of plies may be made with same pulleys without affecting the life, operation, or efficiency of the belt.

Condor Compensated Belts are regularly used for every type of heavy duty drive.

On small pulleys, its remarkable flexibility and compensated ply-tension holds fasteners 3 to 4 times longer than standard belt on the same drive. High starting torques and peak loads up to 100% above normal can be safely handled without excessive slip . . . Condor Compensated is an economical general-purpose belt. A trial will convince you.

Condor LINE

Transmission Belt	Fire Hose
V-Belt	Hydraulic Hose
Conveyor Belt	Steam Hose
Air Hose	Water Hose
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England Reports:

"Battersea is

This "Cathedral of Electricity" is the newest landmark of southwest London—the London Power Company's Battersea Station, England's most modern power plant.

Ultimate capacity will be more than 400,000 Kw., and at present the boiler house contains six units each capable of delivering 330,000 lbs. of steam per hour.

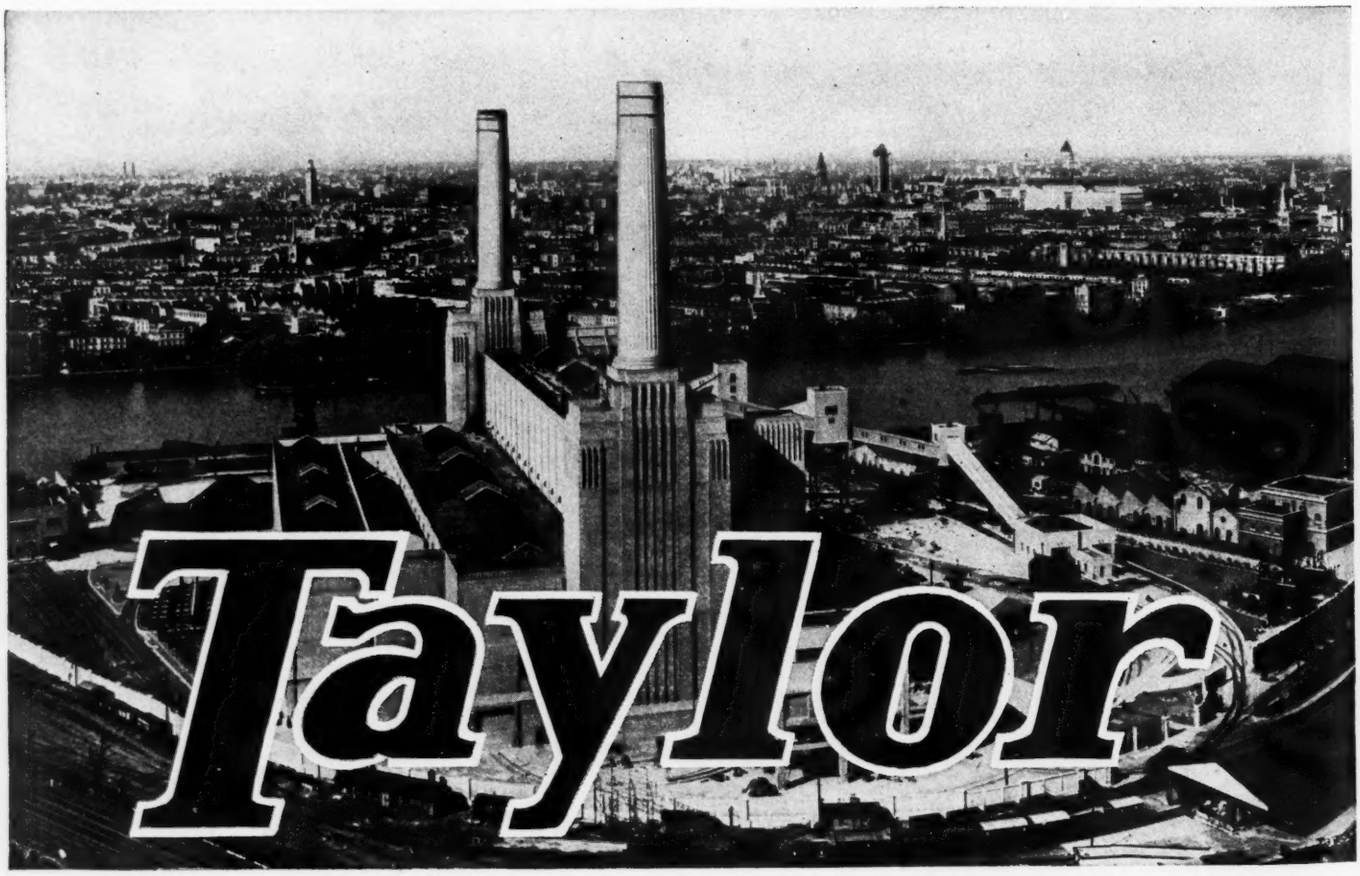
Taylor Stokers fire all six boilers. Each stoker has 20 retorts; width between side walls is approximately 35 ft. The capacity of each unit is 22 tons of coal per hour, or more than 65 lbs. per sq.ft.

Welsh coal is burned, with 16% volatile, 7% moisture, 7% ash, and showing between 13,500 and 14,000 B.t.u. per lb.

The London Power Company is particularly gratified with the ability of the Taylor Stokers not only to burn this coal very successfully but to do so with

AMERICAN

AMERICAN ENGINEERING COMPANY, ARAMINGO AVENUE, PHILADELPHIA, PA.



running well"

almost an entire absence of fly ash. Because of Battersea's location near Buckingham Palace, House of Parliament, Westminster Abbey and many other world famous buildings, this factor is especially important.

Other well-known British plants have had equally successful experience with Taylor Stokers. The City of Bradford has purchased three more 12-retort units with rear water walls and coal chutes. Several units are being erected at Brighton. Three units are now being manufactured for the City of Fulham. And in the near future, Taylor Stokers will be installed in the largest marine stoker project yet undertaken—for the Southern Railway train ferry service.

In England, on the Continent, as well as throughout the United States, the new Taylor Stoker has proved its ability to effect remarkable savings in meeting present-day conditions. If your firing equipment is more than five years old, let us show you the profits possible through modernization. Please address our nearest office.

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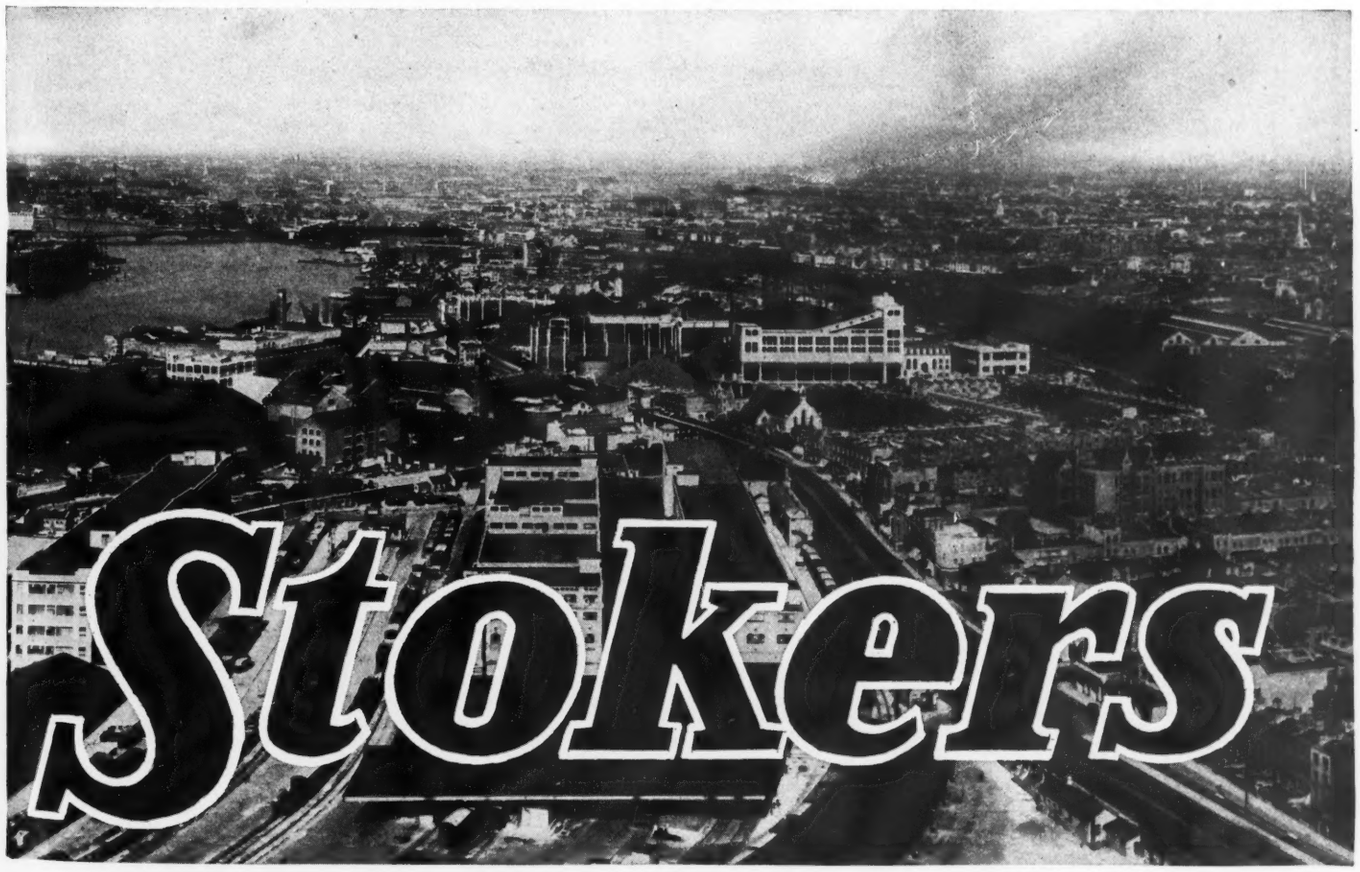
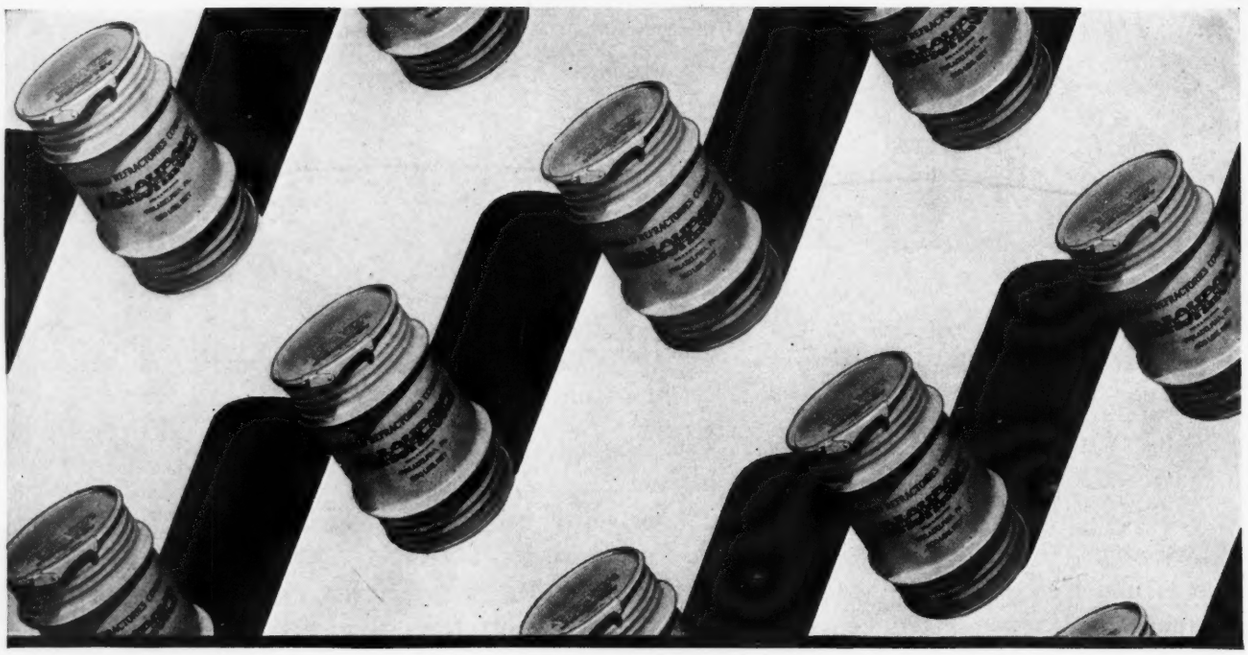
IN CANADA, AFFILIATED ENGINEERING CORPORATIONS, LTD., MONTREAL, P. Q.





YOU NEED *not* PAY MORE!

If you're having refractories troubles because of high temperatures or chemical reactions, you'll be glad to know you now can minimize your troubles without increasing refractories costs.

Today, you can buy ADACHROME Super-Cement—the *only* prepared, ready-to-use chrome base cement whose component materials will not settle out of suspension — at a price comparable to clay base cements, in most localities.

ADACHROME Super-Cement is an air-setting cement with a non-fluxing, non-glazing bond that holds its great strength at high temperatures. Its base of high grade South African chrome ore, being chemically neutral, makes ADACHROME Super-Cement impervious to the attack of most slags, fusible coal ash and other fluxing ingredients in fuels.

For your next setting repair or rebuilding, make a note now to use ADACHROME Super-Cement. A stock of 250-lb. and 500-lb. drums is near you. Ask us where, and for the complete data in a new booklet. Write today for full information.

BOTFIELD REFRACTORIES COMPANY

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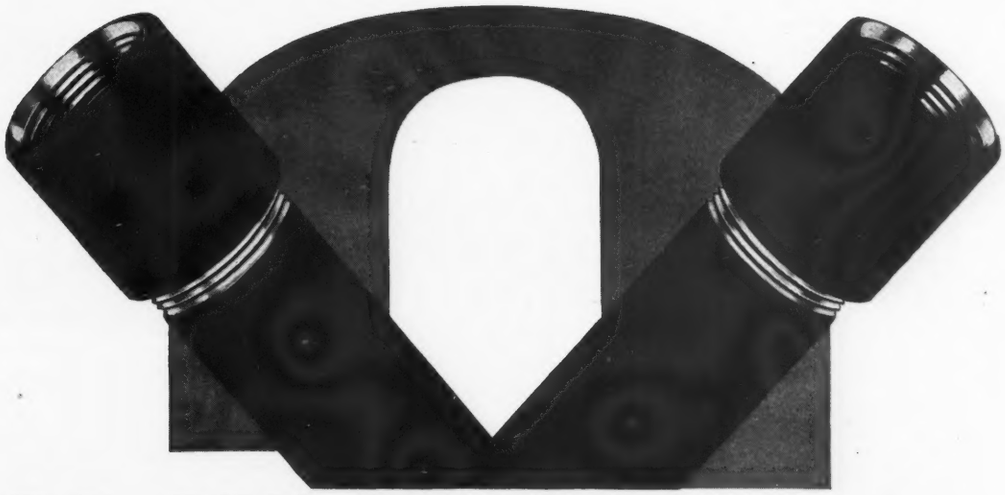
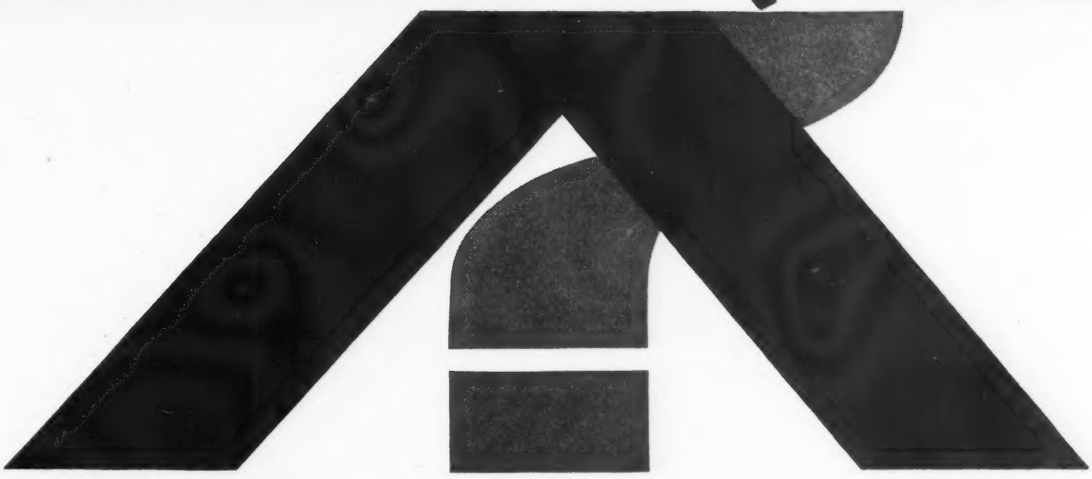
ADACHROME

PLASTIC SUPER-CEMENT



THERE CAN BE NO QUESTION



TONCAN IRON PIPE DOES LAST LONGER

Records of the service given by Toncan Iron Pipe in every type of installation prove conclusively that this modern alloy pipe does last longer. This statement holds true whether it is used in a plumbing or heating system in a building, in process lines in industrial plants, for supply and drainage lines on board ship, or carrying acid mine water far underground.

In the latest edition of "Pipe for Permanence" you will find the records of many comparative tests. And you will also find the technical information that explains why Toncan Iron Pipe consistently renders better service than other ferrous pipe slightly lower in cost.

Toncan Iron Pipe is the only pipe obtainable today that takes advantage of the properties of refined iron, copper and molybdenum to form an alloy that is rust-resisting to a higher degree than any other ferrous material, except the stainless alloys. It is the only pipe that combines with this rust-resisting feature the many advantages that Republic's Electric Weld Process alone can claim—100% perfect weld, straightness, roundness, uniform wall thickness, freedom from inside defects and absence of scale inside and out.

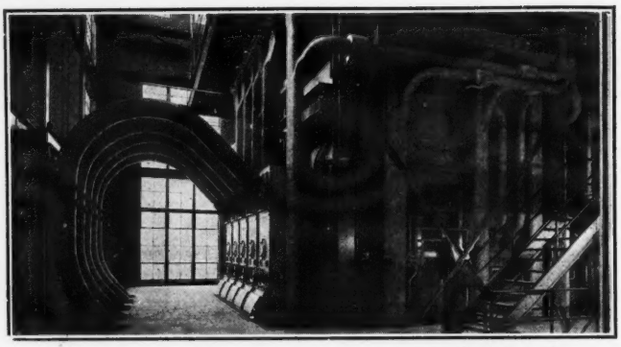
Every pipe buyer should know the facts. A copy of "Pipe for Permanence" will be sent on request.

REG. U.S. PAT. OFF.
TONCAN
COPPER
MO·LYB·DEN·UM
IRON PIPE

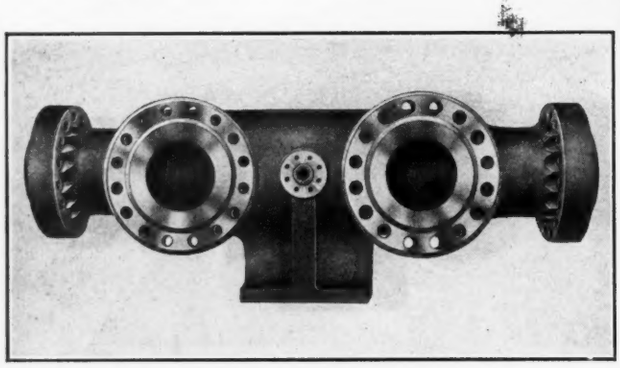
REPUBLIC STEEL CORPORATION

GENERAL OFFICES YOUNGSTOWN, OHIO

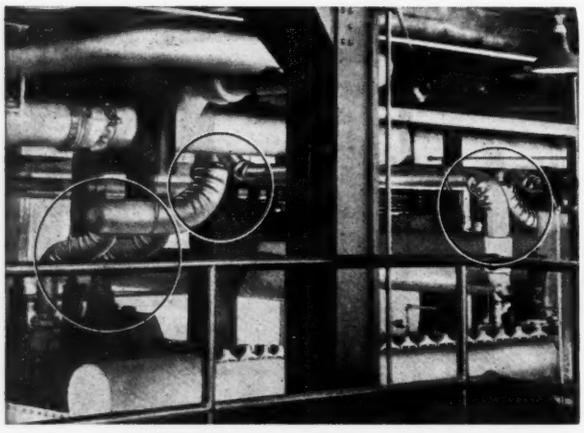
For every POWER PLANT and PITTSBURGH PIPING &



Piping fabricated and installed by Pittsburgh Piping.



Cast Steel Header—4½" wall thickness for service at 800° F. and 1350 lb. pressure.



Creflex Welding Fittings eliminated 12 line welds in the safety valve exhaust piping shown above.

WE congratulate POWER on its Golden Anniversary.

During its fifty years of progress, POWER has rendered a fine service in disseminating valuable information on power generation.

For over three decades PITTSBURGH PIPING has shared with POWER in the growth of utility and industrial power plants through the fabrication and installation of low and high pressure piping materials.

High pressures and temperatures unthought of thirty years ago are now common practice as engineers strive for greater economy.

PITTSBURGH PIPING &

INDUSTRIAL PIPING *Installation* EQUIPMENT COMPANY

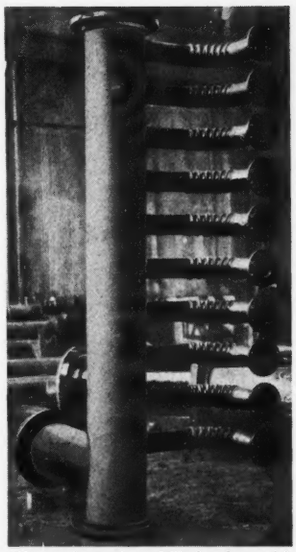
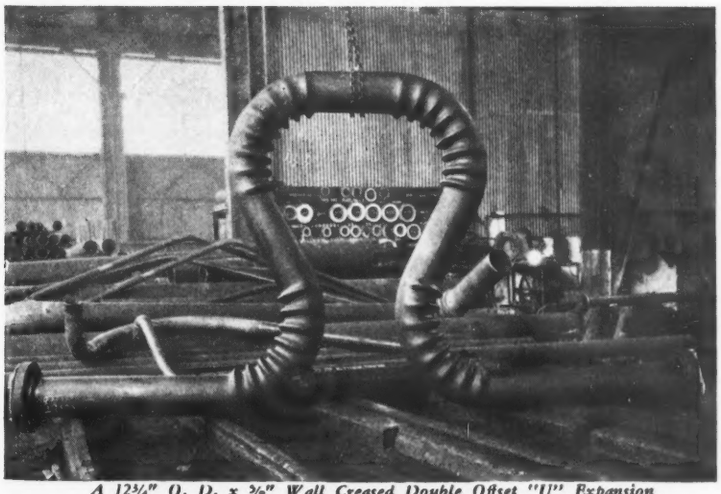


Illustration of a 16" header with 10—5" Creflex Welding Fittings as outlets. Twenty welds were eliminated and a considerable saving in cost was effected by using Creflex Welding Fittings.

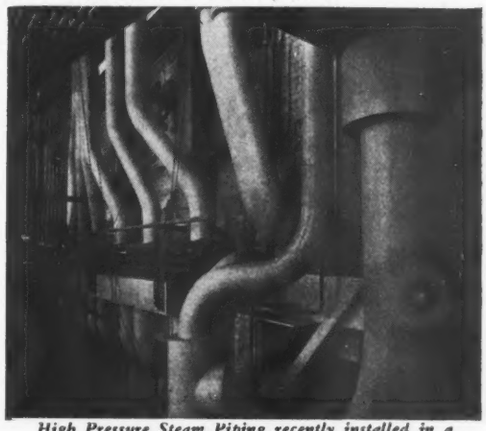


A 12¾" O. D. x ⅜" Wall Creased Double Offset "U" Expansion Bend for Power Plant Service at 600 lb. pressure.

In this period PITTSBURGH PIPING'S cooperation with design engineers has served as a major factor in the development of piping materials to withstand satisfactorily elevated pressures and temperatures. The introduction of Creased Bends and Creflex Welding Fittings are notable examples.

In addition to the above mentioned items, PITTSBURGH PIPING is fully equipped to fabricate and install cast iron and cast steel fittings, pipe bends, offsets, expansion joints, manifolds and pipe supports.

Write direct to PITTSBURGH PIPING & EQUIPMENT COMPANY 43d St. & A.V.R.R. Pittsburgh, Pa., or to our branch offices in New York City, Chicago, Detroit, Boston, Indianapolis and Cleveland.



High Pressure Steam Piping recently installed in a modern power plant.

EQUIPMENT COMPANY

FOLLOW THE TREND TO *Modern*

WINTON-DIESEL engines are built in a wide range of sizes for all kinds of stationary and industrial applications. Their development is an outgrowth of more than twenty years' experience in building Diesel engines. Constant searching for improvement finds its latest and most effective expression in the high detail refinement and simplicity of these advanced-type units. Their performance provides the full benefit of modern Diesel power—proved reliability, economy in operating cost, accessibility of all working parts, special suitability for the service intended. The success of every Winton-Diesel application is insured by correct design and fine workmanship, supplemented by our exceptional resources and facilities for rendering prompt and efficient service.

WINTON ENGINE CORPORATION, CLEVELAND, OHIO, U. S. A.

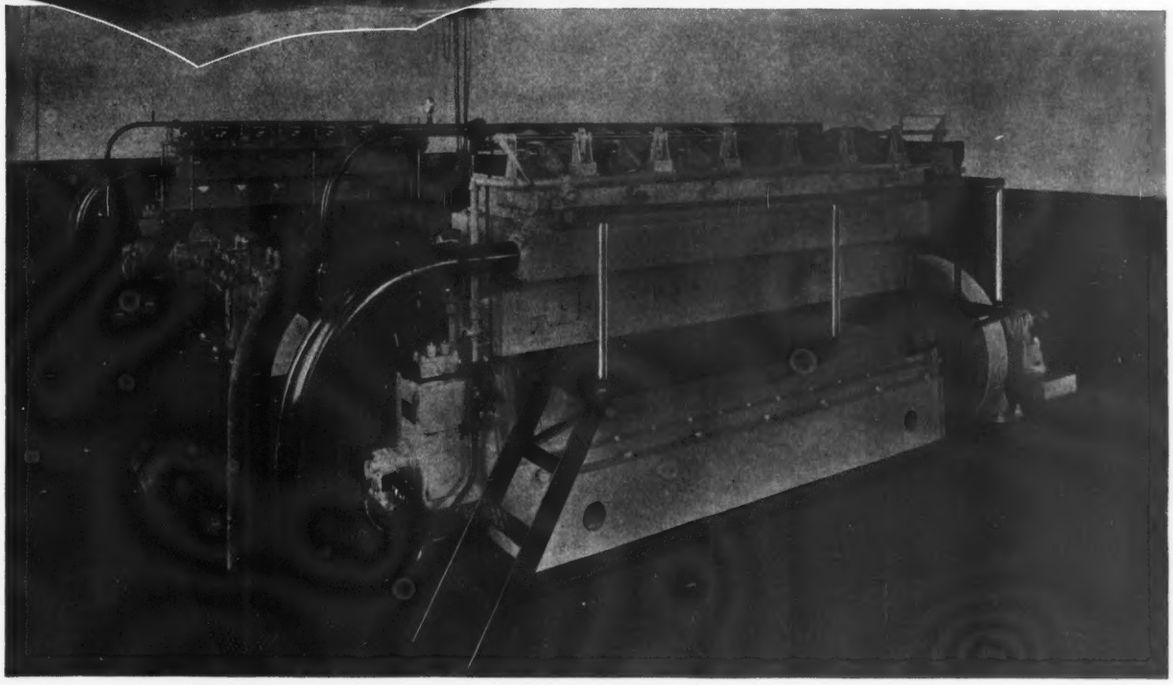
SUBSIDIARY OF GENERAL MOTORS CORPORATION

WINTON

DIESEL POWER

Six-cylinder unit for electric power service. A compact power plant that meets every service requirement.

Simplicity, convenience, and cleanliness, as evidenced in a recent Winton-Diesel application.

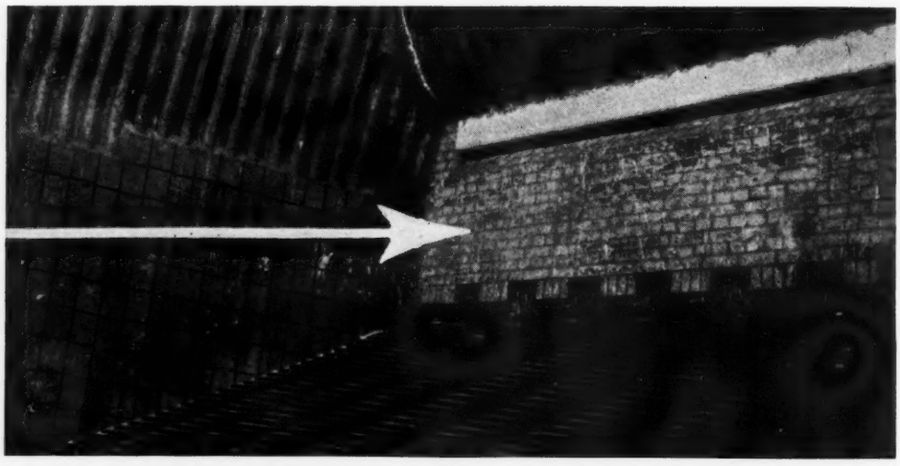


ENGINES

CARBEX

silicon carbide

SUPER-REFRACTORY



CARBEX brick in front wall of one of the 530,000 lbs. per hour steam boilers at the Hudson Avenue Station of The Brooklyn Edison Company—The world's largest stoker fired furnaces.

CARBEX:

1. WITHSTANDS temperatures of 3300° F.—Silicon carbide has a dis-associating temperature of over 4000° F.

2. CARRIES heavy loads at maximum temperatures—Silicon carbide possesses many times the load bearing strength of fire brick.

3. WITHSTANDS abrasion—Silicon carbide is an abrasive as well as a super-refractory.

4. DOES NOT spall—its fused bond and low coefficient of expansion stand extreme changes of temperatures.

5. DOES NOT clinker—its great density and hardness enable it to resist the penetration of slags.

Your copy of Bulletin 232 describing the physical characteristics and economies of CARBEX will be sent on request.

McLEOD & HENRY CO.

1825 TROY, N. Y. 1934

SAVE *with* BY-PRODUCT POWER

A CHALLENGE TO TO YOUR COSTS

Here's the Challenge: By-Product Power claims that it can reduce your costs to a marked degree. The only proviso is that you are using live steam in some way for heating or processing and that you can use either mechanical or electrical power.

Are you game to accept this challenge? Will you put your costs to the test and see what can be done toward reducing them?

Troy-Engberg Steam Engines and Generating Sets enter the picture because they are leaders in making this By-Product Power idea practicable. They deliver in the exhaust steam all the heat units necessary for heating or processing but at no more cost than formerly. They generate, *as a by-product*, either mechanical or electrical power at a cost much lower than it can be purchased or generated directly for that purpose. For many sets of conditions, they will do these two things at a cost much lower than can any other type of equipment.

Typical applications of this By-Product Power idea and records of its Savings are given in an illustrated booklet. Six interesting case studies are discussed, involving six widely varying classes of industry and covering six different requirements. If this challenge of By-Product Power strikes a responsive chord, send for this booklet. It may mean the start toward susbstantial reductions in your costs.

TROY ENGINE & MACHINE CO.
1495 Railroad Avenue, Troy, Pennsylvania

NAME.....

ADDRESS.....

CITY AND STATE.....

WORTHINGTON PUMP AND MACHINERY CORPORATION

WORTH

Nearly A Century

of progressive effort, research and experience have made and kept the name . . .

WORTHINGTON . . . synonymous with

PERFORMANCE

and **SERVICE**

in the power equipment field throughout the world.

1841 — 1934

NRA

WE DO OUR PART

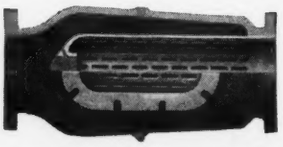
A-3453

General Offices: **HARRISON, N. J.** *District Offices in Principal Cities*

INGTON

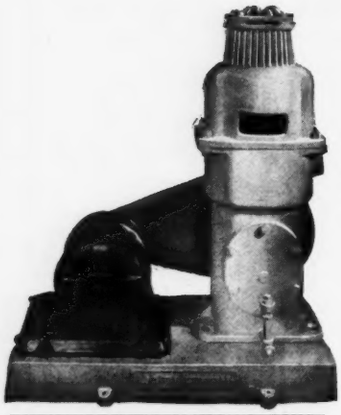
HAZLETON

PUMPING PLANT ACCESSORIES



LARGE-CAPACITY STRAINER

Can be placed anywhere in the suction line. Large hinged hand holes make cleaning very easy.

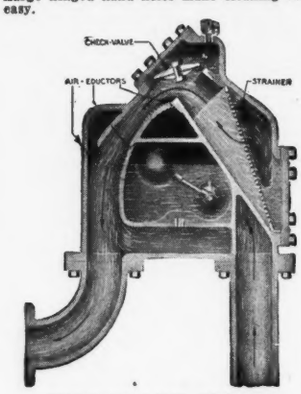


MOTOR-DRIVEN PRIMING PUMP

For priming centrifugal pumps that are either manually or automatically controlled. Five sizes, ranging from 10 to 100 cu.ft. of free air per minute.

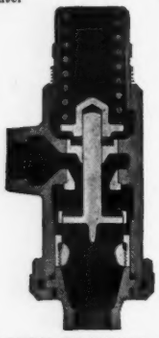
reduce attendance costs in spite of the current trend toward shorter working hours and higher wages. More and more centrifugal pumps are being converted to "Automatic Control" by owners who are already familiar with the dependability and economy of Automatic Pumping.

Your control conditions are no more unusual than the hundreds of applications already made, and we welcome your request for further details.



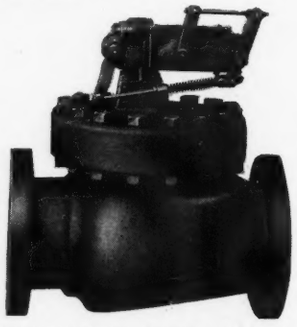
SUCTION LINE PRIMER

Automatic priming devices with built-in check valve and strainer. Requires no extra motor. Suitable for manual or full-automatic pump control.



AUTOMATIC PRIMING VALVE

Remains closed as long as pump runs, and opens automatically to admit priming water when pump stops and loses its pressure.



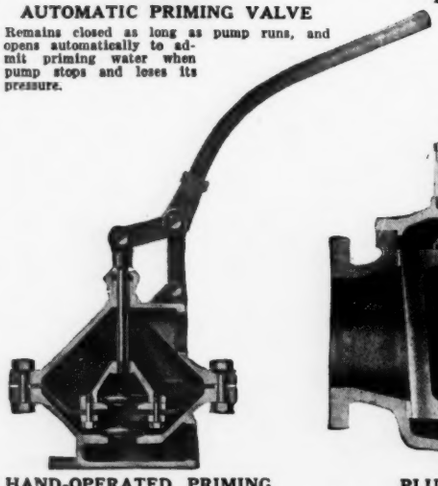
HEAVY-DUTY CHECK VALVE

With finger-contact flow switch. When properly connected this switch will stop the pump as soon as it ceases to deliver water, thus protecting it from damage.

BARRETT, HAENTJENS & CO.

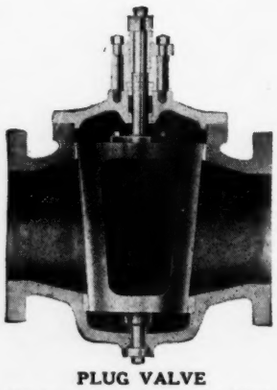
HAZLETON, PA.

PITTSBURGH, PA. ST. LOUIS, MO.
BIRMINGHAM, ALA. HOUGHTON, MICH.



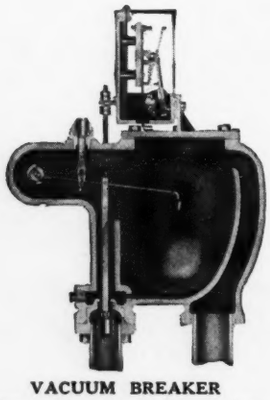
HAND-OPERATED PRIMING PUMP

Diaphragm type, with bronze valves, and housing of either bronze or cast iron. Two sizes, the larger size equipped with double handle for two-man operation.



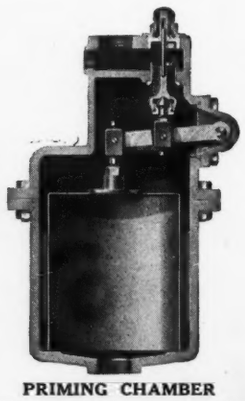
PLUG VALVE

Can be used for years without deterioration in lines carrying corrosive water. Outlasts gate valves many times.



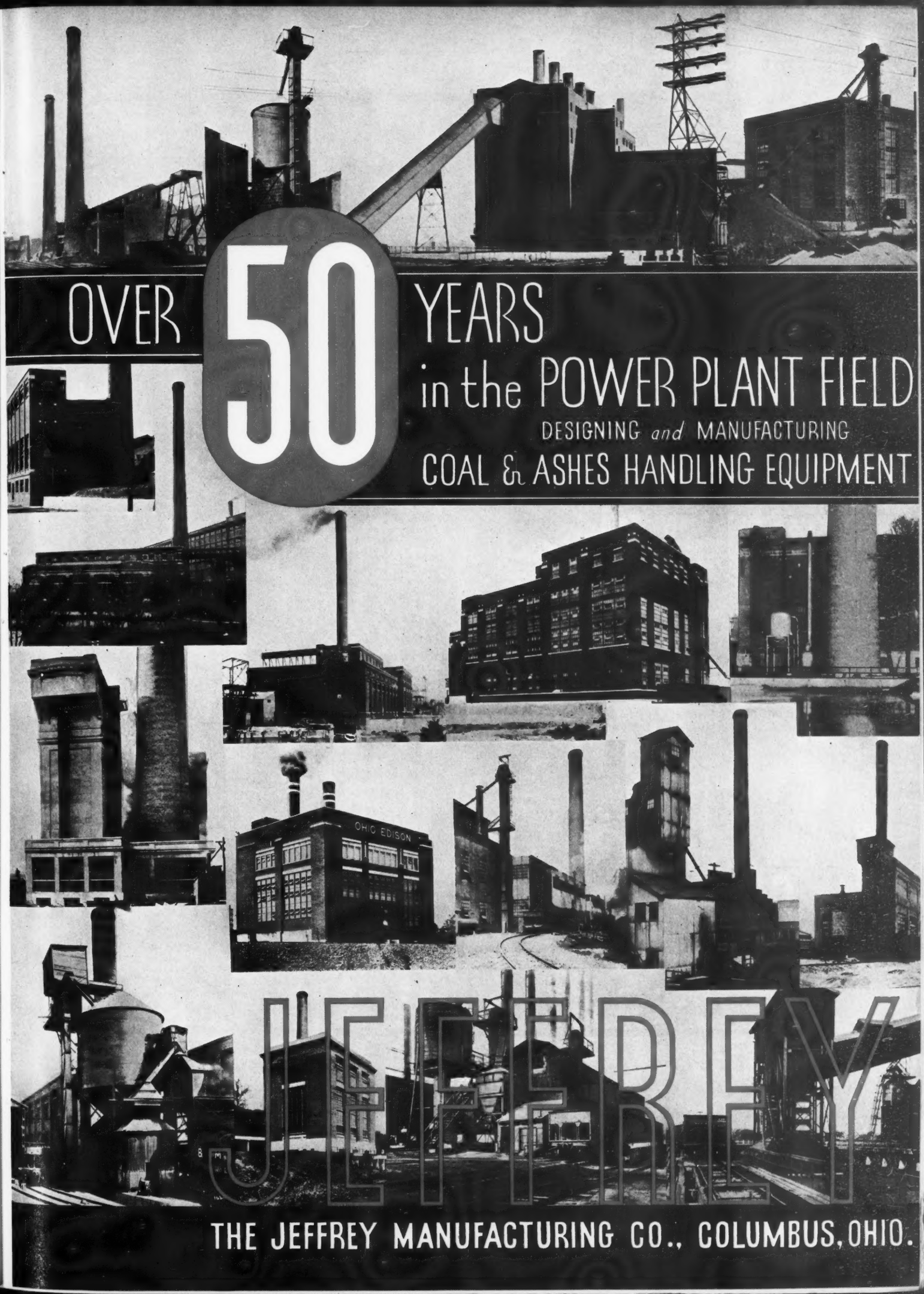
VACUUM BREAKER

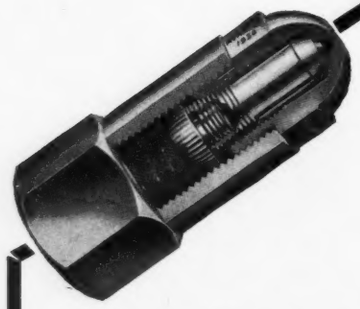
Prevents the entrance of water into priming pump after air has been drawn from centrifugal pump and section line. Applied to both manual and automatic control.



PRIMING CHAMBER

Combines priming valve and float chamber in a single unit. Its purpose is to expel air, and its switch can be arranged to stop the priming pump or to start the centrifugal pump.


OVER 50 YEARS
in the POWER PLANT FIELD
DESIGNING and MANUFACTURING
COAL & ASHES HANDLING EQUIPMENT
OHIO EDISON
JEFFREY
THE JEFFREY MANUFACTURING CO., COLUMBUS, OHIO.



MONARCH PERFECTION SPRAY NOZZLES FOR WATER

Many industries have need for direct pressure *fine* spray nozzles. With this F-27 series Monarch Perfection nozzle, water is broken up into the finest spray possible with direct pressure — no air or steam as the atomizing medium.

Applications are so many and varied we will not attempt to enumerate them, except to say that sizes from 4.50 to 12.00 are suitable for use in Domestic Air conditioners, and are usually tested 80 deg. at 25 lbs.

Spray Angle: To get best results nozzles should be tested to the desired spray angle at about the pressure at which they will be operated. *Unless otherwise specified, all nozzles will be tested to 80 deg. included angle at 80 lbs. pressure on water.* Small and intermediate sizes can be tested down to 30 deg. depending upon pressure, while with larger sizes minimum angle will be about 60 deg. Maximum angle can be about 100 deg.

Nozzle Marking: These nozzles will be marked for capacity as per first column in table (the capacity at 100 lbs. pressure on #2 furnace oil), the spray angle (which will be at 80 lbs. unless otherwise ordered) and the letter W, to indicate that they have been tested on water. To the best of our knowledge this is the first comprehensive list giving uniformity of design and closeness of capacity ranges.

Liquids on which to be used: These nozzles having stainless steel tip and disc, will resist corrosive action from both water or salt water, etc., quite well, but are not recommended for use on anything more viscous than water. If intended for use on oil, etc., then inquire for information.

Orders should state: Quantity
Nozzle No. (see first column)
Operating pressure
Spray angle desired.

High Pressures: If nozzles are to be used on high pressures—over 150 and up to say 3,000 lbs., then inquire about Fig. 621-MP.

Special Bodies: Sometimes for air conditioning work angular bodies are desired. Such bodies can be furnished to order. Thimble strainer, however, cannot be used.

CAPACITIES IN GALLONS PER HOUR

Nozzle No.	Lbs. Operating Pressure							Min. Pr.	Code Word	List Prices
	25	30	35	40	60	80	100			
1.35				.57	.69	.83	.92	40#	Chest	
1.65				.75	.89	.99	1.12	"	Chide	
2.00			.87	.94	1.14	1.28	1.40	35#	Chief	
2.50		.98	1.01	1.13	1.45	1.64	1.86	30#	Child	
3.00	1.03	1.15	1.23	1.39	1.62	1.85	1.95	25#	China	For Lots Under 50 $4.60
3.50	1.36	1.50	1.64	1.77	2.11	2.46	2.80	"	Chink	
4.00	1.56	1.70	1.82	2.00	2.42	2.77	3.16	20#	Chips	
4.50	1.86	1.95	2.11	2.32	2.77	3.21	3.68	"	Chirp	
5.00	2.20	2.44	2.34	2.88	3.57	4.09	4.59	"	Chive	
5.50	2.22	2.48	2.71	2.96	3.75	4.31	4.78	15#	Choir	
6.00	2.55	2.91	3.16	3.35	4.01	4.78	5.23	"	Choke	For Lots Over 50 $3.08
7.00	2.90	3.31	3.58	3.91	4.60	5.17	6.00	"	Chord	
7.60	3.16	3.40	3.65	4.09	5.00	5.62	6.43	"	Chuck	
8.30	3.57	3.80	4.20	4.67	5.62	6.42	7.03	"	Chump	
9.50	3.81	4.20	4.60	4.89	6.20	7.03	7.89	"	Chunk	
10.50	4.10	4.80	5.00	5.42	7.25	8.33	9.00	"	Churn	
12.00	4.75	5.20	5.60	6.17	7.50	8.65	9.60	"	Chute	For Lots Over 500 $2.64
13.70	6.34	6.85	7.40	8.00	9.60	10.70	12.17	"	Chyle	
15.30	6.81	7.45	8.00	8.65	10.70	12.17	13.63	"	Cider	
17.15	7.25	8.20	9.00	9.60	11.80	13.23	14.51	"	Cigar	
19.50	10.00	11.00	11.70	12.40	15.00	17.30	18.17	"	Cinch	
21.50	10.46	11.40	12.40	13.23	16.07	18.00	20.40	"	Civic	
24.00	11.84	12.70	13.60	15.00	17.73	20.40	23.18	"	Civil	
30.75	15.00	16.30	17.40	18.17	22.50	25.00	30.00	"	Claim	

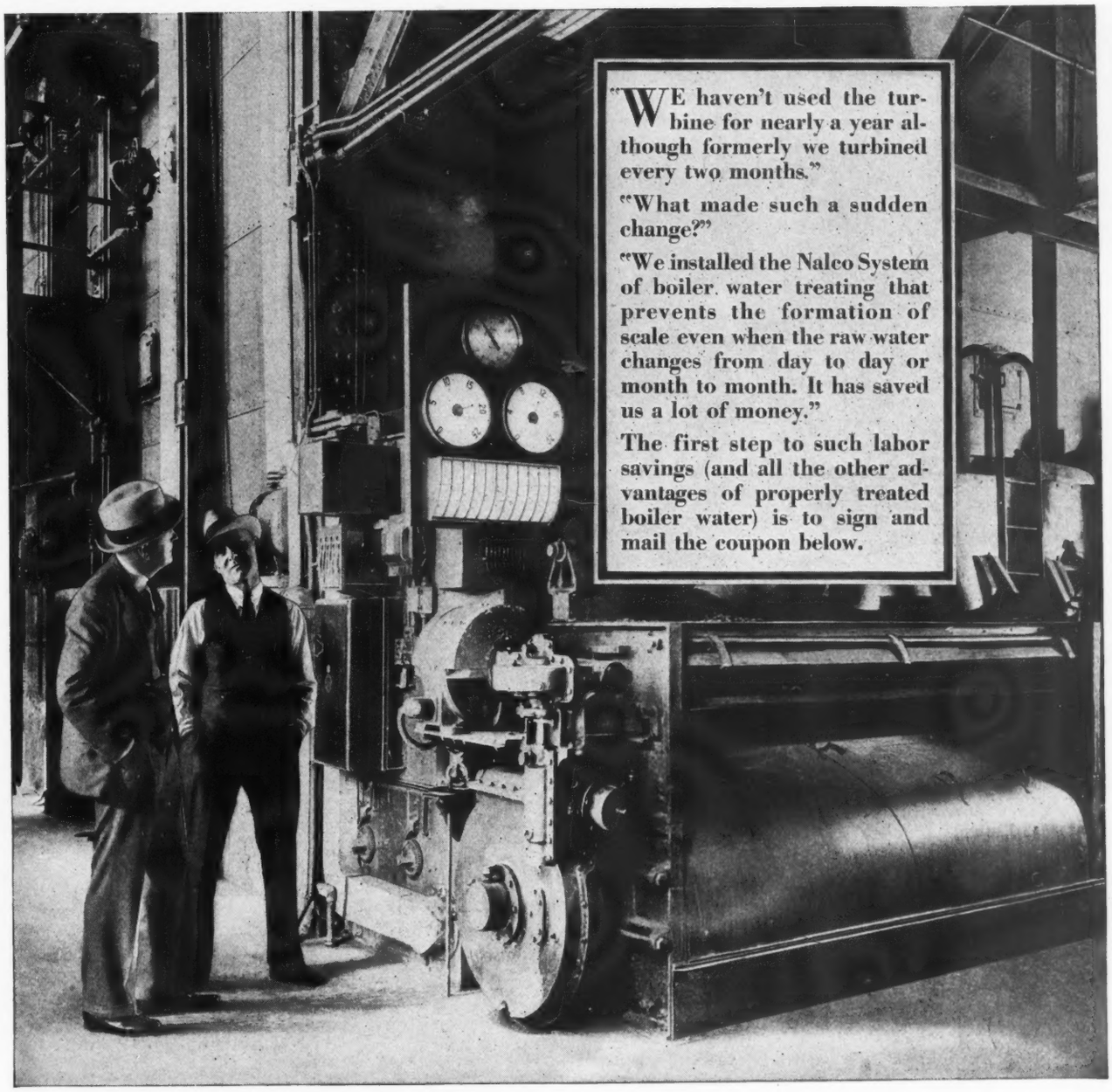
CAT. 6-C covers also Ash Quenchers, Re-Cooling Nozzles, Stoneware, Hard Rubber and regular brass spray nozzles.

MONARCH

MONARCH MFG. WORKS, INC.

2731 EAST WESTMORELAND ST., PHILADELPHIA, PA.

"How often do you need to turbine your boilers?"



"WE haven't used the turbine for nearly a year although formerly we turbined every two months."

"What made such a sudden change?"

"We installed the Nalco System of boiler water treating that prevents the formation of scale even when the raw water changes from day to day or month to month. It has saved us a lot of money."

The first step to such labor savings (and all the other advantages of properly treated boiler water) is to sign and mail the coupon below.

SODIUM ALUMINATE *(Nalco System)*

NATIONAL ALUMINATE CORPORATION
6222 W. 66th Place, Clearing Sta., Chicago, Ill.

NRA MEMBER U.S. WE DO OUR PART

- ☐ Send me your free booklet, "Standardized Feedwater Treatment."
- ☐ Have an engineer make a feedwater survey of my plant. This does not obligate me in any way.
- ☐ Give me names of nearby Nalco users or companies with plants similar to mine.

Name .....
Title .....
Company .....
Address .....
Type of Plant .....
City ..... State .....

There's a Nalco representative near you. (The Flox Co., Minneapolis, Minn., exclusive representatives in the Northwest)

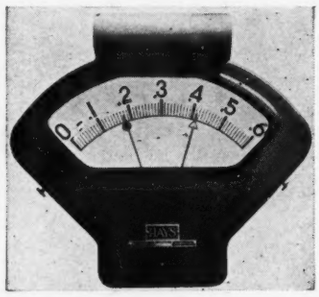
THE HAYS INSTRUMENTS FAMILY OF GAGES

"B" TYPE

Same features as "J" type. Also sold as portable gage with reel for tubing, carrying handle, case, etc. Also sold as electric contact gage with bullseye to light. Offered for either high or low contact service or for both for use as control. Equipped with closed mercury switches or open contacts, depending on your service conditions.

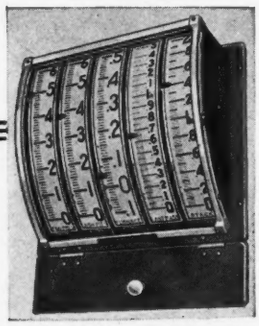
"J" TYPE

Similar to "F" type but smaller in size and housed in a cast aluminum case. Can be supplied with one or two units and scales. To keep price low we standardize only on six popular scale ranges that read in inches water: ½", 1", 2", 6", and 10", and one balanced range for draft or pressure reading. Special ranges can be furnished.



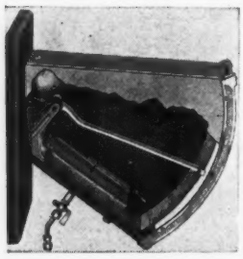
"F" TYPE

Available for wall mounting or flush panel mounting. Furnished with one or two pointers and with one scale and one diaphragm mechanism, one scale and two mechanisms, or two scales with two mechanisms. There are instances when both units of a two pointer "F" type gage can be calibrated for the same range. This means but one scale and two differently colored pointers. On a natural draft installation the spread between pointers shows the draft loss.



"V" TYPE

Such important operating information as wind box or burner pressure, furnace draft, steam pressure, steam temperature, flue gas temperature can be indicated by individual scales. Internal illumination, smooth pointer movement, any desired range or mounting, any number of units. The hinged access door at bottom of case makes it possible on panel mounted gages for one man to close a cock or make an adjustment from the front while observing the scales and pointers--and other exclusive features.



SLACK LEATHER DIAPHRAGM

Developed and introduced by Hays. The slack leather diaphragm mechanism has been adopted for use in thousands of the finest power plants of the world. This outstanding and exclusive improvement gives a new and most dependable way to indicate and record low ranges of drafts and pressures. It provides the utmost in sensitivity without the use of liquids.

SIMPLE OPERATING MECHANISM

This phantom view of the "V" type mechanism shows the extreme simplicity and ruggedness. It consists essentially of the slack leather diaphragm in a die cast housing and a phosphor bronze cantilever spring attached to a duraluminum pointer. The spring is harnessed directly to the pointer in the simplest possible manner, only one bearing being required.

SPECIAL PIVOT BEARING

A hardened, stainless steel pivot held by phosphor bronze bearing screws is the only bearing required for pointer arm. It is our own development, superior to the finest jewel bearings for this particular purpose. The stainless steel pivot does not ride on its hardened point but against a hardened ring of phosphor bronze just off the point.

DRY TYPE POINTER GAGES

for

DRAFT — PRESSURE — DIFFERENTIAL — TEMPERATURE

The name Hays has been synonymous with efficient boiler room operation for more than thirty years. During this time the complete Hays family of gages was developed so that there is a type of highest readability, sensitivity and accuracy for every need. When a Hays Gage is installed fuel savings follow.

WHY HAYS GAGES ARE EXTENSIVELY USED

The following benefits are being obtained with Hays Gages and you can get the very same results. Users determine the most efficient conditions—Reduce excess air and flue gas temperatures—locate leaks in settings and baffles—Eliminate guesswork—Standardize firing practice — Reduce furnace maintenance and maintain proper steam pressure. Scales can be selected for your ordinary operating range as there are no liquids to evaporate or be blown out and sudden excessive pressures do no harm.

THE HAYS CORPORATION
MICHIGAN CITY, IND. U. S. A

COMBUSTION INSTRUMENT SPECIALISTS SINCE 1901

Send for Bulletins

« OTHER HAYS INSTRUMENTS »

Combustion Recorders for CO_2 Draft and Flue Gas Temperatures.
Portable Combustion Test Sets.
Flue Gas Analyzers.
Portable Gas Colorimeters.
Ignition Velocity Meters for Gas.
Specific Gravity Recorders for gases and liquids.
Complete Boiler panels.

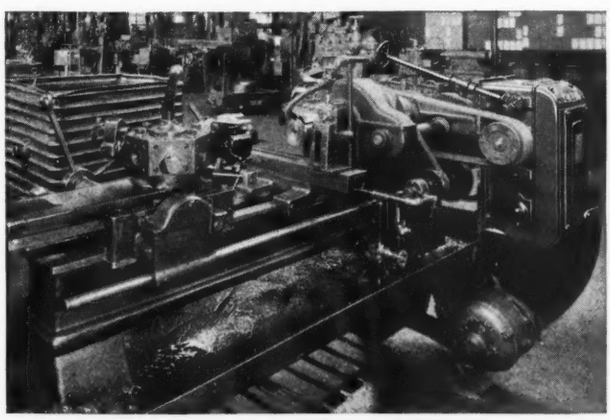
SENSITIVE VARIABLE SPEED CONTROL

APPLIED TO NAP-RAISING DEVICE
(Teaseling Gig—Textile Industry)

REEVES Transmission used because *extremely sensitive* speed control is essential in raising nap on different fleece and woolen materials to proper depth.

APPLIED TO PAPER UNWINDING MACHINE

Two REEVES Transmissions, equipped with Automatic Control, provide *sensitive* speed flexibility for maintaining *smooth, uniform flow* of paper from feed rolls to corrugating machine and for keeping these two units *perfectly synchronized* in speed.



APPLIED TO SCREW MACHINE

Any spindle speed from 139 r.p.m. to 556 r.p.m. is instantly and accurately available on this screw machine, because it is equipped with REEVES *sensitive* speed control. Results: the *correct* speed for each set-up, better quality work and faster production.

☆ ☆ SENSITIVE speed control is required to give *complete speed flexibility* to production machines. Fine gradations of speeds *over a wide range*—quick, precise response *while machines are running*—absolute accuracy in *maintaining* any speed as long as desired! These requirements have made the REEVES Variable Speed Transmission industry's *approved* method of speed control. . . . Power delivery is always positive *at any speed,* due to *time-tested* REEVES V-belt. Speed settings are held *without* fluctuation under varying loads, due to patented automatic belt tension control. The REEVES is available in a *complete range* of speed ratios, sizes, controls, compact designs (with or without unit motor mounting) for quick and easy application to any driven machine. Over 80,000 in use today in 16,000 plants. Standard equipment on 900 different makes of machines. Draw on this unequalled experience for *correct* application of speed control in your plant.

SEND FOR THIS VALUABLE BOOK ON SPEED CONTROL

REEVES PULLEY COMPANY
COLUMBUS, INDIANA 6-34

Send, without obligation, Catalog P-99 and special information on applying variable speed to.....

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Company.....

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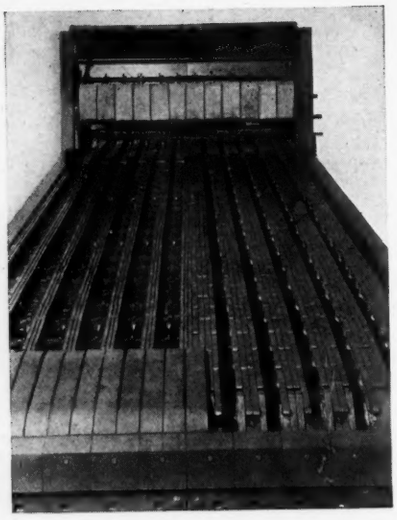
STOWE STOKERS

Produce exceptional economy

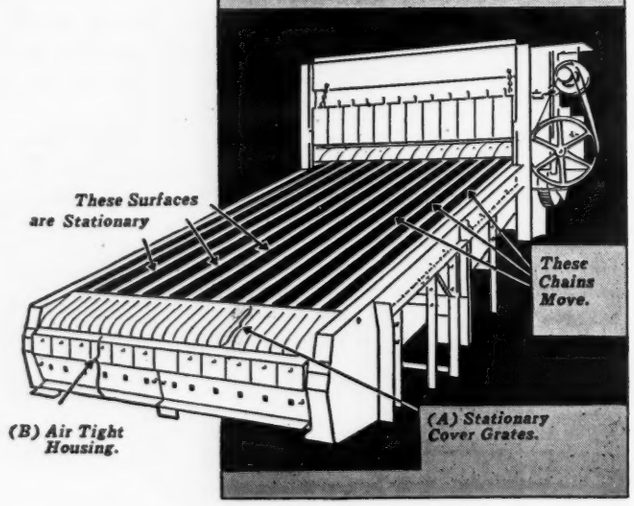


HERE IS WHY—

THEY consist of a combination of moving chains and stationary grates. 35% of the grate area does not move.

These fixed grates retard the movement of the fuel bed, keeping it compressed, without fissures, as the fuel, moving back, diminishes in volume by burning. This action keeps a uniform compact fire, prevents air leakage through, and automatically slows the movement as volume diminishes. The ash compresses against a cast iron bridge air seal at the rear, before it passes over, assuring its retention long enough to remove all combustible.

Hence, Stowe Stokers prevent air leakage that would cool the furnace and waste fuel—and uses all the combustibles. This stoker is given highest praise by all users for its exceptional fuel economy. Maintenance is negligible in amount, producing further savings.



These Seven Points Make Stowe the Stoker to Buy

1. *Compensated* Feed
2. Absolute *uniform* fuel bed
3. Permits use of wide range of fuel
4. *Smokeless* operation at all ratings
5. Full wind box pressure under entire grate area
6. Freedom from operating manipulation
7. Up to *40%* fuel saving

THE JOHNSTON & JENNINGS CO.
ADDISON ROAD, CLEVELAND, OHIO

STOWE STOKERS

"Flexitallic"
REG. U.S. PAT. OFF.
SAFE
Gaskets so constructed that they pay for themselves in prevention of blow-outs and in reduction of follow-up.
SELF-ADJUSTING
Metal plies pre-formed to produce *mechanical* resilience. Response to variations in temperature and pressure is instant and automatic.
RESILIENCE RETAINED BY PATENTED FEATURES
Reinforcements, exclusive to Flexitallic Gaskets, prevent "spread," thus keeping gaskets fully resilient through several installations. Resulting length of service minimizes costs.

STEADILY MORE USERS OF FLEXITALLIC GASKETS

in POWER PLANTS

Conditions of recent years have not retarded growth in the number of plants regularly using Flexitallic Gaskets. In Power Plants, as well as in the Oil and Chemical Industries and the Shipping Trade, customers have actually increased. The number is now greater than at any previous time.

There is no explanation other than the merits of the gaskets in service. Our selling policy has been only to set forth the principles of Flexitallic construction, pointing out that, on a work-factor basis, the gaskets show the user an exceedingly low cost.

The result has been, first, trial installations; second, continuous growth in customers.

TWO IMPORTANT ADDITIONS TO THE FLEXITALLIC LINE

Self-Centering Gaskets for:

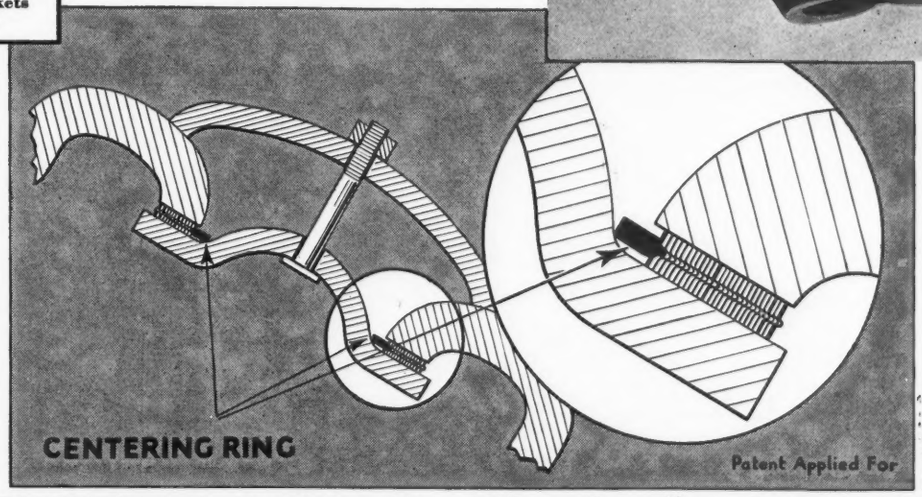
1. BOLTED FLANGES

Centering ring, illustrated at right, keeps entire gasket between flanges. Joint failure, owing to radial misplacement, eliminated. Applicable to Raised Face, Van Stone, Cranelap and Plain Face flanges.

2. MANHOLE OPENINGS

Centering ring, illustrated below, keeps the entire gasket between bearing faces. No pinching or shouldering, even though openings and cover-plates differ in diameter.

Send for our Catalogue and then TRY Flexitallic Gaskets



This Will Bring Full Explanation by Mail

Flexitallic Gasket Co., 8th and Bailey Sts., Camden, N. J.

GENTLEMEN: Please send catalogue information with regard to—Pipe Flange Gaskets —Manhole Gaskets

Name.....

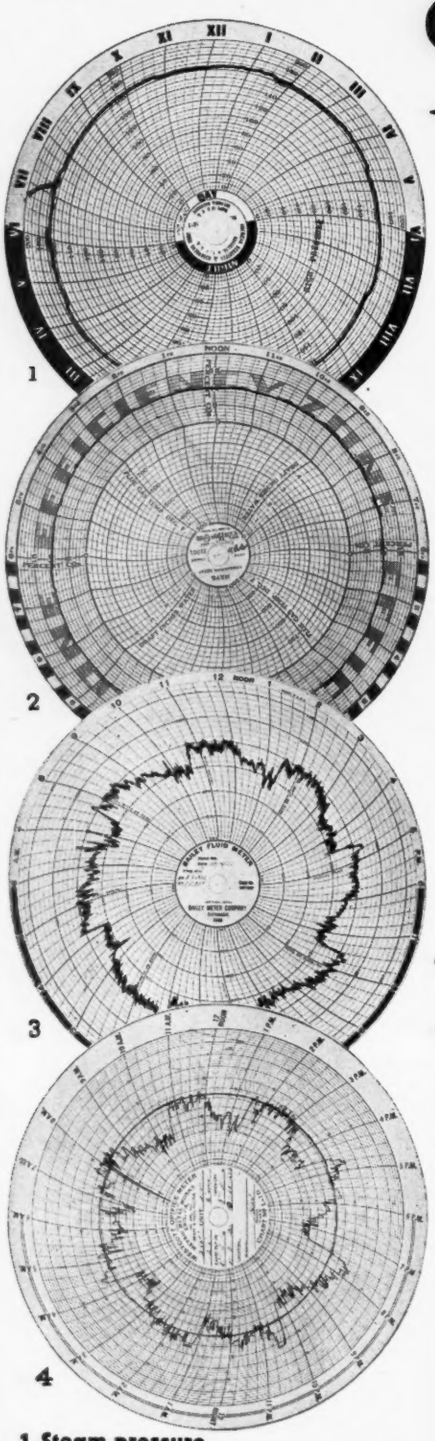
Plant.....

City.....State.....

FLEXITALLIC GASKET CO., 8th and Bailey Streets, Camden, N. J.

Can you afford to keep on tolerating fuel losses, now that those losses can be eliminated by

The DFC Automatic Combustion Control?



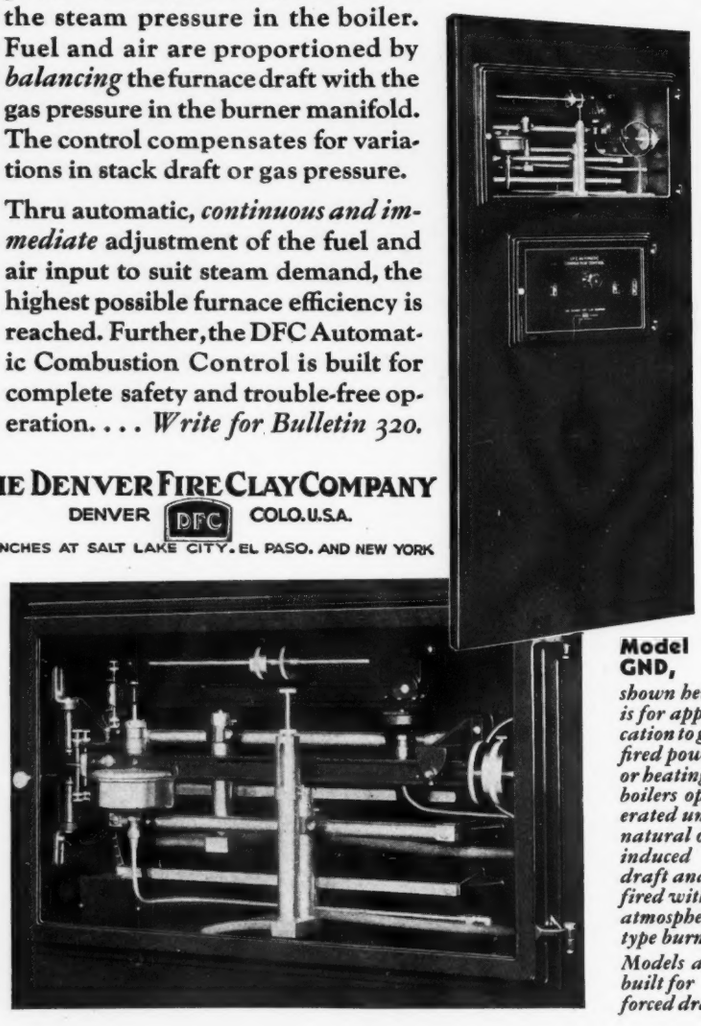
1 Steam pressure
2 CO_2
3 Steam flow
4 Gas flow

COMPARE THESE CHARTS WITH YOUR OWN! This DFC controlled plant consists of eight gas-fired 260 HP boilers operated at 220% of rating at peak loads . . . not equipped with economizers or pre-heaters. *Averages 78% efficiency.*

The DFC Automatic Combustion Control . . . is a truly PROPORTIONING control. Fuel input is controlled by *balancing* the gas pressure at the burner header with the steam pressure in the boiler. Fuel and air are proportioned by *balancing* the furnace draft with the gas pressure in the burner manifold. The control compensates for variations in stack draft or gas pressure.

Thru automatic, *continuous and immediate* adjustment of the fuel and air input to suit steam demand, the highest possible furnace efficiency is reached. Further, the DFC Automatic Combustion Control is built for complete safety and trouble-free operation. . . . *Write for Bulletin 320.*

THE DENVER FIRE CLAY COMPANY
DENVER DFC COLO. U.S.A.
BRANCHES AT SALT LAKE CITY, EL PASO, AND NEW YORK



Model GND, *shown here, is for application to gas-fired power or heating boilers operated under natural or induced draft and fired with atmospheric type burners. Models also built for forced draft.*

THERE'S NO SUBSTITUTE FOR SKILL

SKILL... A 75 YEAR TRADITION

● HEWITT skill, as embodied in today's list of Hewitt industrial rubber products, testifies to a time-honored Hewitt tradition. For three quarters of a century of uninterrupted growth, Hewitt has sought to build better and better belting, hose and packing as experience has pointed out improved methods, finer materials, and better machines.

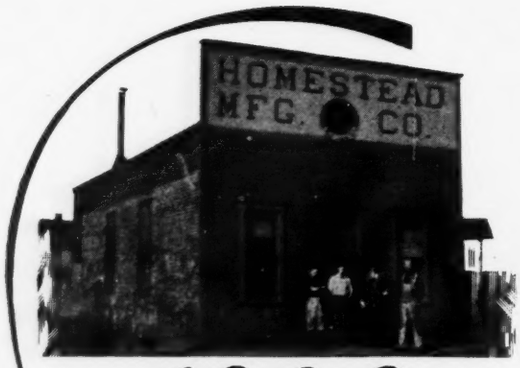
Such an attitude of open-mindedness has been instrumental in developing Hewitt skill to an enviable position . . . not only in the construction of industrial rubber goods, but in their correct application to specific sets of conditions.

If you are not using Hewitt products in your plant, or if you are faced with a rubber problem which has not been satisfactorily solved, either from the standpoint of wear, efficiency, or cost, a Hewitt engineer will be glad to call on you . . . Hewitt engineers are available through distributors in industrial centers. Hewitt Rubber Corp., Buffalo, N. Y.

HEWITT RUBBER CORPORATION

THE GUTTA PERCHA & RUBBER MANUFACTURING CO. EST. 1859 . . . HEWITT RUBBER COMPANY. EST. 1904

HOSE CONVEYOR AND TRANSMISSION BELTS PACKING



1892

ACCEPTANCE
The Forerunner of
PROGRESS

• Only the broad and popular acceptance of Homestead Products has made it possible for this company to depict its progress of 42 years, as shown by the contrast of its plant of 1892 with that of 1934. Acceptance was the forerunner of progress and quality gave Homestead acceptance.

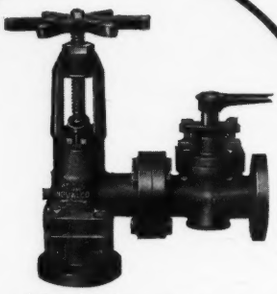
The Homestead quarter-turn valve, our first product, immediately reduced ultimate costs and maintenance, and freed the engineer from the constant trouble he experienced with the average valve of that day.

From time to time we have added Hovalco blow-off valves, Homestead protected seat hydraulic operating valves (B & O Patents), Homestead spray valves, lift type plug valves, all of which have lived up to and enhanced the reputation of the quarter-turn valves. We also make special valves of all materials.

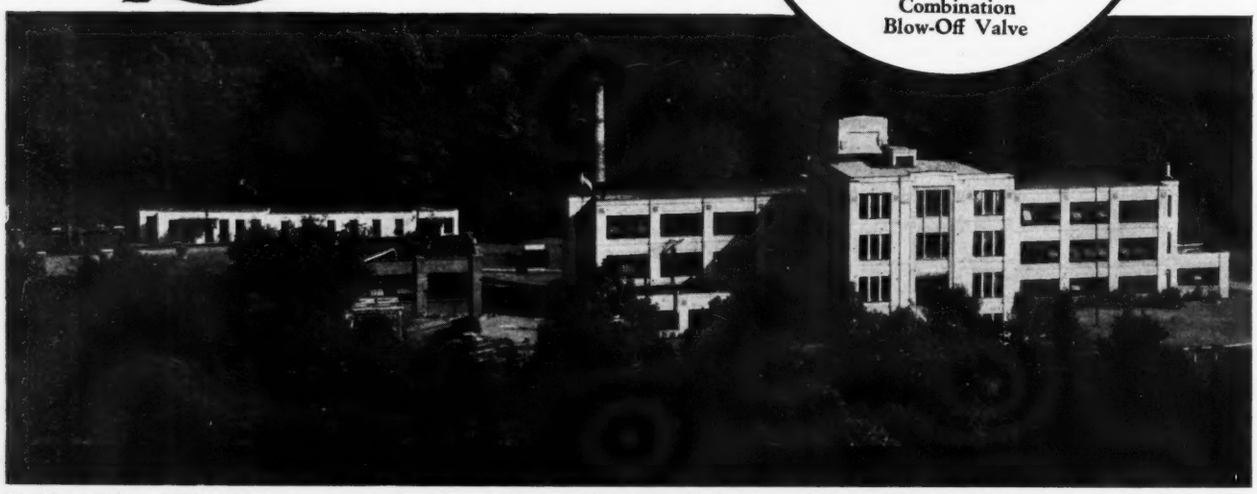
The unvarying quality of our product has assured this steady, sound growth.

HOMESTEAD VALVE MANUFACTURING CO.
CORAOPOLIS, PA.

1934

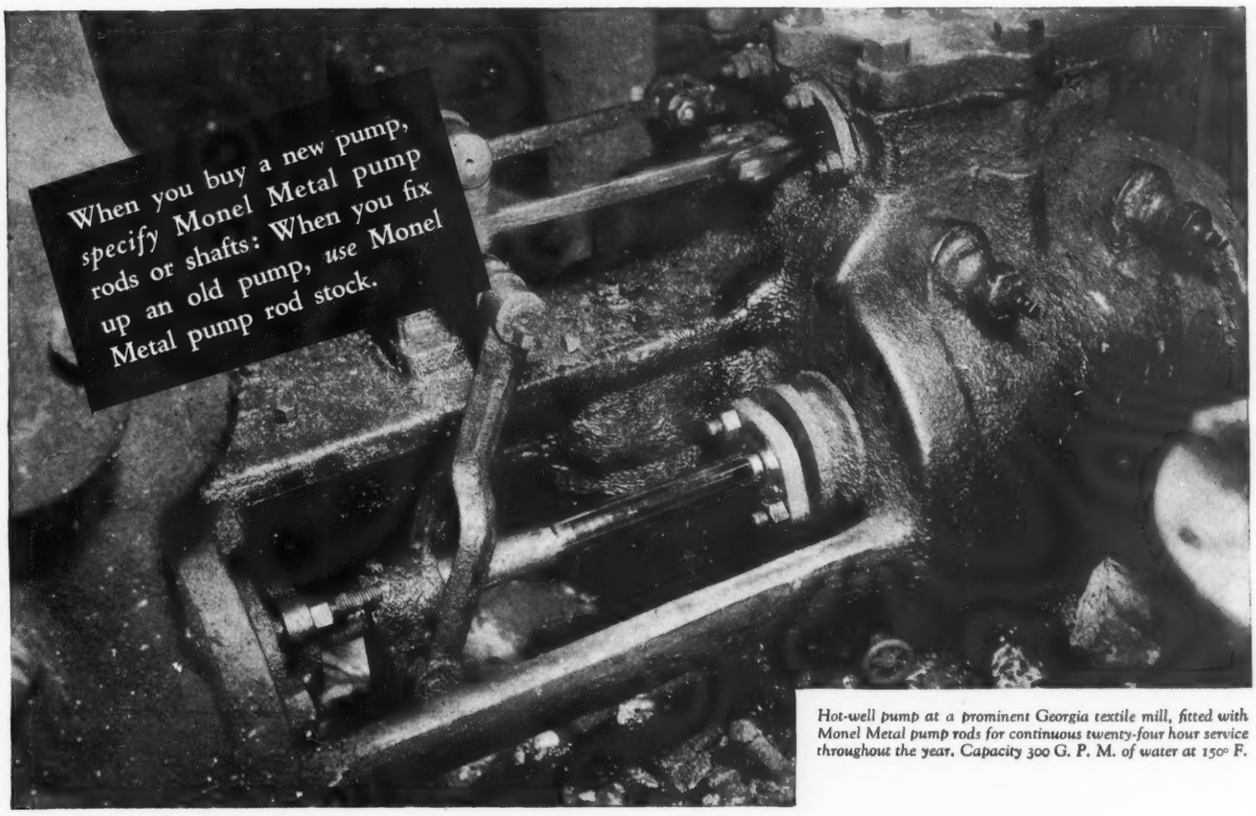


Hovalco-Homestead
Combination
Blow-Off Valve



Boiler Blow-Off Valves . . . Quarter Turn, Straight-Way, and Four-Way Valves . . . Protected Seat Spray and Operating Valves . . . Homestead Ross Air Valves
Hypressure Jenny for Vapor Spray Cleaning

NO 'TIME OUT' *for this hard-working Pump!*



Hot-well pump at a prominent Georgia textile mill, fitted with Monel Metal pump rods for continuous twenty-four hour service throughout the year. Capacity 300 G. P. M. of water at 150° F.

Its Monel Metal pump rod delivers 24-hour service on a tough job... saves labor and shut-down losses, not to mention steam and packing

THIS hot-well pump at a Georgia textile mill runs 24 hours a day. Its capacity is 300 G.P.M. of water at 150° F.

Read what the engineer in charge says about its Monel Metal pump rod—

"During the past few years we have had occasion to replace a number of bronze and steel pump rods with Monel Metal rods, and find that due to Monel acquiring a much higher polish, the tendency for the rod to score due to pressure of packing, etc., is minimized. "Also due to its non-corrosive properties, we find less trouble from a service standpoint where pumps are operating under intermittent service.

"All pumps ordered by us for the past year have called for Monel Metal rods."

The tough strength of a Monel Metal pump rod, its absolute immunity to rust, and its dense, cold-drawn structure save power, packing and the pump rod itself.

For a Monel Metal pump rod, once it has 'polished in', needs only a 'finger tight' adjustment of the gland for a perfect seal. This gives it friction-free action, reduces wear at packing and bearings to a minimum and is one of the reasons why a Monel Metal pump rod outlasts other rods many times over.

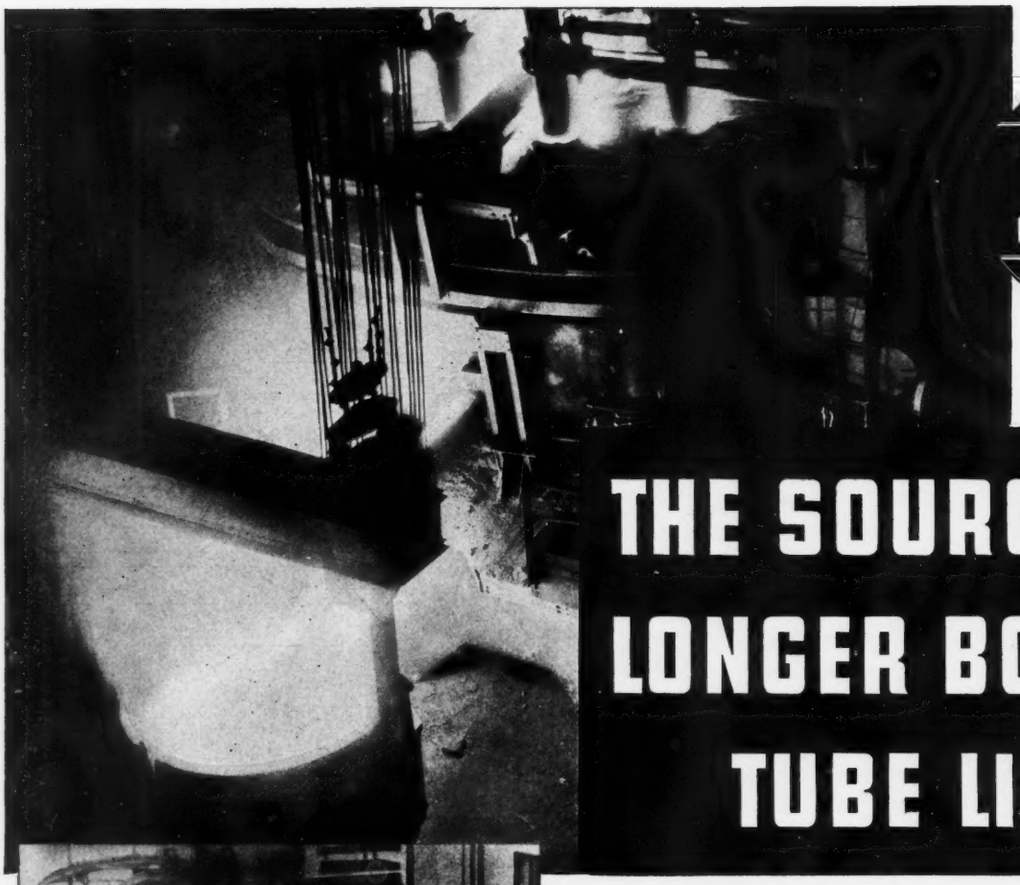
Write for prices, sizes and machining instructions.

See the INCO *Exhibit of*
Monel Metal Household Appliances
at A Century of Progress, Chicago—1934
Home Planning Hall

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall St., New York, N. Y.

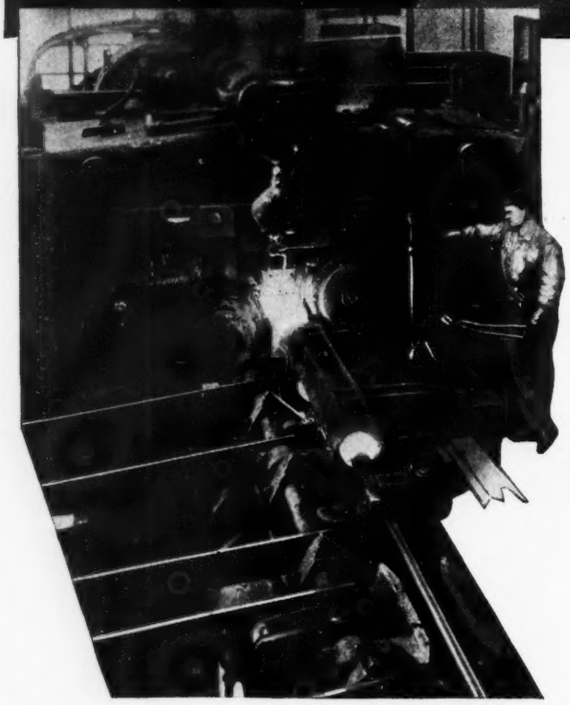
Monel Metal is a registered trademark applied to an alloy containing approximately two-thirds Nickel and one-third copper. Monel Metal is mined, smelted, refined, rolled and marketed solely by International Nickel.

Monel Metal



GOOD WILL BASED ON GOOD STEEL

THE SOURCE OF LONGER BOILER TUBE LIFE



WITH the object of bettering the service obtainable from boiler, superheater and condenser tubes—with particular emphasis on the reduction of tube failures under extreme operating conditions—Timken metallurgists and field men have made an intensive study of the possibilities of modern alloy steels for this class of work.

From these experiments have emerged Timken alloy steels possessing greater reserve strength. Manufactured with characteristic Timken care in a modern plant where every precaution is taken to assure consistently high quality and uniformity, tubes fabricated from these steels offer you an opportunity to avoid some of the delays and losses incidental to tube failures.

Any boiler tubes may be "good enough" until an emergency calls for reserve strength. That is when Timken Alloy Steel Tubes justify their use.

THE TIMKEN STEEL AND TUBE COMPANY, CANTON, OHIO

District Offices or Representation in the following cities: Detroit Chicago New York Los Angeles Boston Philadelphia Houston Buffalo Rochester Syracuse Tulsa Cleveland Erie *World's Largest Producer of Electric Furnace Steel*

TIMKEN STEEL TUBES

ELECTRIC FURNACE AND OPEN HEARTH - ALL STANDARD AND SPECIAL ANALYSES

Unretouched Photograph

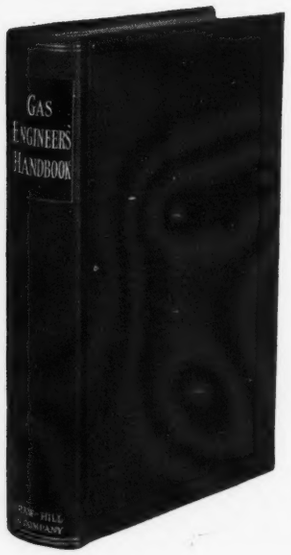
LOOK *at the* INSIDE—

THAT'S WHAT REALLY COUNTS

Work a little experiment now, and learn once and for all whether or not Tube-Turns are the fittings you want to buy! Here's how: Cut one in half, as shown in the photo. "Mike" the walls. You'll see that Tube-Turns are (1) uniform in wall thickness at points—no thinning of the back wall, where strength is needed; no buckling of inner wall, where *smoothness* is needed . . . . You will see (2) that Tube-Turns line up with the pipe on *both* inside diameter *and* outside diameter—which is obviously impossible where wall-thickness is not uniform . . . . You'll see (3) that the effective radius of Tube-Turns is actually 1½ times the nominal pipe diameter—is *not* reduced by straightened ends . . . . You'll see (4) that Tube-Turns are *NOT* merely pipe bends, but are as smooth and as uniform and as dependable as straight pipe. ● Don't be confused by outside appearances. Cut up a Tube-Turn *and see the difference for yourself!* Tube-Turns, Incorporated, 404 Herald-Post Building, Louisville, Ky.

TUBE-TURNS

Standard
McGRAW-HILL BOOKS
for Power Plant Engineers



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Prepared by Gas Engineers' Handbook Committee of Pacific Coast Gas Association; Reviewed by Technical Section of American Gas Association. Brings together physical, chemical, thermodynamic and other constants and formulas used most frequently by gas engineer in his work. Gives useful fundamental information; covers all phases of gas industry, including gas manufacture, testing, measurement, transmission, distribution, and utilization, both industrial and domestic. 1008 *pages.*

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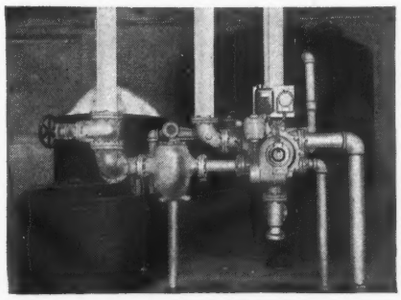
● *Permutit engineers will make a free survey of your plant and show you how you may be able to save thousands of dollars every year by the elimination of scale, sludge, and mud through proper water treatment.* This is no pipe-dream! Here are the facts!

In 20 years, Permutit has built and installed water treating equipment for over 9,000 boiler plants. This equipment was built for hard daily usage to give efficient service for less money, year after year. It was designed to save fuel, cut boiler-tube maintenance costs, actually pay for itself in savings within a short period of time. Records of our customers prove these savings.

More than that, Permutit is constantly testing new uses, new appliances, and new water treating equipment to assure you even greater savings in the coming years.

Right now, Permutit has a dollar-saving answer for every modern-day problem of water treatment. No pipe-dream promises . . . but effective, economical equipment proved by years of service. Study the list at the side. Check the equipment your plant needs.

Let us make a free survey of your plant and recommend suitable water treatment. First, write for a free copy of "No Scale, No Sludge, No Mud," a study of water treatment savings you can't afford to pass by. Write: The Permutit Company, 330 West 42nd Street, New York, N. Y.



● Permutit Automatic Zeolite Water Softener. Lowers the cost of producing soft water. No over-running. No under regeneration. Automatic controls can be applied to existing equipment.

Permutit Products

Equipment for removing hardness from water
- (1) Zeolite Water Softeners
- (2) Hot Process Lime Soda Water Softeners
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Equipment for removing other impurities dissolved in water
- (1) Zeolite Type Iron and Manganese Removal Filters
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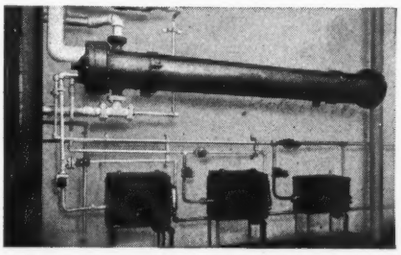
- (4) Color Removing Equipment
- (5) Activated Carbon Filters

Equipment for removing impurities suspended in water
- (1) Filters for Clarifying Water
- (2) Oil Removing Filters
- (3) Mechanical and Chemical Type Iron and Manganese Removal Filters

Equipment for feeding chemical solutions to water
- (1) Automatic Apportioning Pressure and Gravity Feeds

Continuous blowoff systems
- (1) For Boilers
- (2) For Evaporators

Ranarex gas density machines
- (1) For Determining CO_2 in Flue Gas
- (2) For Measuring Specific Gravity of Illuminating Gas
- (3) For Determining Ammonia in Ammonia-Air Mixtures
- (4) For Determining Specific Gravity and BTU in Butane Air Mixtures
- (5) For Other Applications Where Gas Density May Be Used as a Guide to Operation



● Permutit Continuous Boiler Blowoff Equipment. For continuously maintaining the desired concentration in boilers, with recovery of heat from the blowoff water.

Permutit
Water Treating Equipment

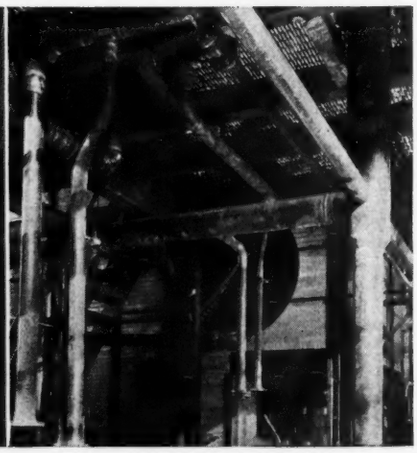
"WE ORDER EVERYTHING FOR OXWELDING AND CUTTING FROM LINDE"

CONFIDENCE . .
in Oxwelded Piping
and Linde Process Service

THE contract called for an oxy-acetylene welded piping installation and the contractor bid with confidence—knowing Linde Process Service would help.

Linde service operators helped the foreman to qualify his regular men, completing their grasp of the latest developments in pipe welding. They were instructed in making templets for special fittings, shown how to fabricate the boiler headers and how best to use welding in erecting the mains and risers.

Oxwelding can be used to join pipe of any metal, and for any type of piping service. Here a weld is being made in brass pipe.



In an installation of steel pipe, such as this, Lindewelding—the high speed, low cost method of joining pipe—can be used to advantage.

When that job was finished the piping contractor had an organization skilled in welding, ready to tackle more and bigger oxwelded pipe installations. He appreciates that when he buys from Linde, the full benefits of the oxy-acetylene process are assured to him through Linde Process Service.

Linde Process Service can bring to your piping problems also the widespread experience Linde has acquired in over twenty years of pioneering and developing oxy-acetylene applications. It will interpret for you the latest methods developed in the laboratory and show you how to apply them profitably to your own actual welding and cutting operations. This service is supplied to Linde customers without obligation.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

126 Producing Plants UCC 627 Warehouse Stocks

IN CANADA, DOMINION OXYGEN CO., LTD. TORONTO

LINDE OXYGEN • PREST-O-LITE ACETYLENE • OXWELD APPARATUS AND SUPPLIES • UNION CARBIDE

PRODUCT OF A UNIT OF UCC UNION CARBIDE AND CARBON CORPORATION

Users of products and processes developed by Units of Union Carbide and Carbon Corporation benefit from a most unique coordination of scientific research with manufacturing, sales and service facilities. You are cordially invited to visit this summer the numerous exhibits sponsored by the Corporation in both the Basic and Applied Science sections in the Hall of Science at Chicago's 1934 A Century of Progress Exposition.

Sales Offices:

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NRA WE DO OUR PART

NO HEAT WASTE HERE!

This 90°—45° ell with 400 lb. non-return valve on main steam line carries 400 lbs. of steam at 700° F. . . . heat loss checked by 4 inches of Eagle "66" Plastic Insulation.

● If your hands get cold, don't try to warm them on this steam line — even though it is carrying 400 pounds at 700° F. Eagle Insulation keeps the heat where it belongs, inside the line. That means just two things: low operating costs; high operating efficiency.

So that you can get acquainted with the full line of Eagle industrial insulating materials for a complete range of temperatures, we are listing a few Eagle varieties here and asking you to write for free samples of any of them that you would like to examine.

IN BUSINESS 91 YEARS

EAGLE INDUSTRIAL INSULATION

THE EAGLE-PICHER LEAD COMPANY, DEPT. P6, CINCINNATI, OHIO

• Manufacturers of a full line of industrial insulating materials for a complete range of temperatures. Representative products:

Eagle "66" Plastic Insulation
Plastic insulation, easily applied, extremely efficient up to 1800° F.

Eagle "20" Asbestos Cement
Inexpensive short asbestos fibre cement.

Eagle Stalastic (boiler setting cement)
Tough, rubbery plastic, eliminates air infiltration through masonry, boiler, furnace walls.

Eagle Insulseal (waterproofing cement)
Durable coating protects all heat insulation against deterioration.

Eagle Blanket Insulation
Insulating wool felted and secured, for boilers, breeching, oil refinery equipment, furnaces.

Eagle "99" Finishing Cement
Easily applied, efficient, adheres to hot or cold surfaces, dries hard, durable.

The public utility system of

Standard Gas and Electric Company

includes

The California Oregon Power Company
Duquesne Light Company (Pittsburgh)
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Mountain States Power Company
Northern States Power Company
Oklahoma Gas and Electric Company
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Pittsburgh Railways Company
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serving 1,665 cities and towns of twenty states . . . combined population 6,000,000 . . . total customers 1,600,780 . . . installed generating capacity 1,584,079 kilowatts . . . properties operate under the direction of Byllesby Engineering and Management Corporation, the Company's wholly-owned subsidiary.

POWER

MARCH, 1894.

Dearborn Vegetable Compounds.

When you get through trying the "patent medicines" and want your boiler cleaned, send us a gallon of feed water, prepaid by express and receive a copy of the analysis free with a proposition at what figure we can handle your case.

F. E. MARINER, Chemist.

PROPRIETORS,

W. H. EDGAR, Manager.

DEARBORN D

MANUFACT

See Note in the Business Items.

RIALTO

WORKS, HYDE PARK, ILL.

Early Announcement of

Dearborn

TRADE MARK REGISTERED

WE HAVE NEVER MINCED WORDS — OR RESULTS

THE EARLY DEARBORN LABORATORIES

Dearborn Congratulates "Power" — *a valuable ally*

On this fiftieth birthday, Dearborn congratulates and compliments "Power." During the greatest half century of progress ever known, "Power" through its splendid editorial pages and Dearborn through the introduction of science in boiler water treating, have worked constructively.

The "Case Method" described in the old announcement reproduced above is the Dearborn Method employed today, but nearly a half century of research and experience have enriched the effectiveness of Dearborn results. The single formula boiler compounds have about disappeared. The "Case Method" has survived and Dearborn, pioneer exponent of this method, has been called upon to extend its service over the civilized world. Keeping abreast with progress, new designs, higher pressures, heavier demands have found Dearborn always prepared to supply the water correction required. If you are not using Dearborn Treatment, let us send one of our representatives to discuss your water problem with you, collect samples and without obligation, submit recommendations.

DEARBORN CHEMICAL COMPANY

310 South Michigan Avenue, CHICAGO — 205 East 42nd Street, NEW YORK

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SECTION OF NEW GREATER DEARBORN LABORATORIES

Represented in

Baltimore, Md.—Birmingham, Ala.—Boston, Mass.—Cincinnati, O.—Cleveland,O.—Dayton,O.—Davenport, Ia.—Denver, Colo.—Des Moines, Ia.—Detroit, Mich.—Fort Worth, Tex.—Indianapolis, Ind.—Kansas City, Mo.—Little Rock, Ark.—Los Angeles, Cal.—Milwaukee, Wis.—Minneapolis, Minn.—Nashville, Tenn.—Oklahoma City, Okla.—Peoria, Ill.—Philadelphia, Pa.—Pittsburgh, Pa.—Rochester, N. Y.—Saginaw, Mich.—St. Louis, Mo.—San Antonio, Tex.—San Francisco, Cal.—Syracuse, N. Y.—Tulsa, Okla.—Barcelona, Spain—Buenos Aires, Argentine—Calcutta, India—Havana, Cuba—Honolulu, T. H.—Johannesburg, S. A.—London, Eng.—Manila, P. I.—Montreal, Quebec—Sydney, Aus.—Wellington, N. Z.—Rio de Janeiro, Brazil—Lima, Peru—Oruro, Bolivia—Santiago, Chile.

After the roses and confetti have been brushed aside, the cold stark fact remains: **That POWER could never have continued to serve over a 50-year period had it not continuously operated at a profit—which enabled it to so man the paper that the subscriber also profited.**

●

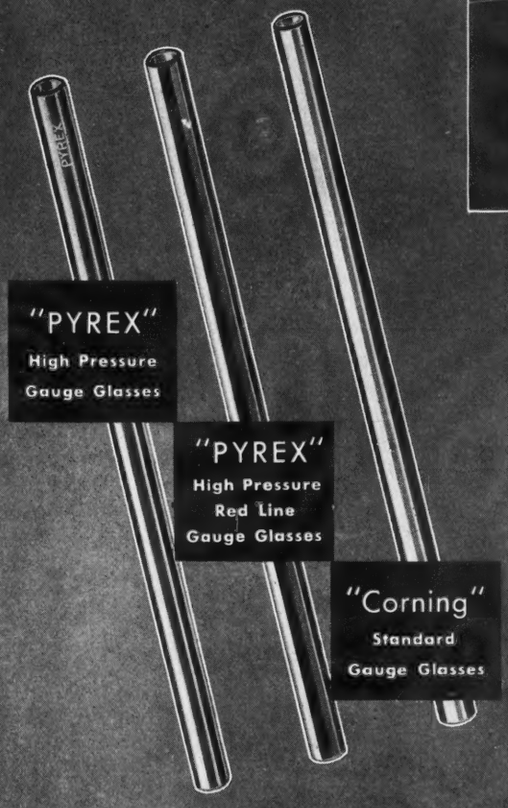
THE SUPERHEATER COMPANY AND THE AIR PREHEATER CORPORATION • 60 EAST 42nd STREET, NEW YORK • CONTEND THAT IT IS ONLY THROUGH THIS MUTUALITY OF PROFIT THAT YOUR BUSINESS AND OUR BUSINESS CAN SURVIVE AND *ADEQUATELY SERVE*

●

A-873

SUPERHEATERS • AIR PREHEATERS • GRIFFIN HOT BLAST • WATER WALLS • ECONOMIZERS

FROM FURNACE TO ICE WATER



PLUNGED from a furnace heat of 425° F. into ice water! That is a test that "PYREX" Brand Gauge Glasses alone can meet. They are practically immune to heat breakage in boiler room service.

Another outstanding property of "PYREX" Brand Gauge Glasses is chemical resistance. This means less corrosion from boiler waters—a clearer gauge glass even after long service.

And the precision of machine drawing assures accuracy of dimensions and ease of installation.

"PYREX" High Pressure and "PYREX" Red Line High Pressure Gauge Glasses are designed for pressures up to 450 lbs. per square inch, but are available in standard lengths for higher pressures. Glasses are also available for lower pressures up to 200 lbs. per square inch, for low pressure boilers, tanks and coffee urns.

Sold by leading dealers in steam supplies. Send for Folder 1-A, giving sizes, prices and detailed information as to why the use of "PYREX" Gauge Glasses means less breakage, longer life, less trouble and genuine economy.

"PYREX" is a trade-mark and indicates manufacture by

CORNING GLASS WORKS • Corning, N. Y.

PYREX BRAND GAUGE GLASSES

ALL-METAL JOINTS

—the effective Smooth-On method of preventing gasket blow-outs

SMOOTH-ON Corrugated Iron Gaskets laid up in Smooth-On No. 3 compress and set as an all-metallic filling conforming to every void and surface irregularity of the flange faces.

This all-iron combination, *without organic body matter*, with nothing to shift position, to decompose chemically or to weaken physically, *simply must* stay in place and make a perfect seal, as the response to temperature and pressure change and vibration are exactly the same as in the adjacent solid metal. The seal is permanent until the joint is intentionally opened, when a knife-blade thrust pries the old gasket from its seal.

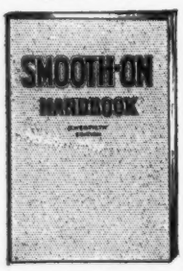
That theory and practice agree in these respects, is proven by wide use of Smooth-On Corrugated-iron Gaskets and Smooth-On No. 3 where no previously tried material and construction would hold for any great length of time. Among such installations are joints on lines subjected alternately to high-pressure highly superheated and low-pressure saturated steam, or steam, water, air and ammonia cylinders, and on flanged connections or couplings subjected to continuous vibration, to water hammer, etc.

Make a test at any troublesome joint, and see for yourself.

Get Smooth-On Corrugated Iron Gaskets in any pipe size up to 26 in., and Smooth-On No. 3 in 1-lb. or 5-lb. can or 25-lb. keg. At your supply store or if necessary, direct from us.

The SMOOTH-ON HANDBOOK FREE if you return the coupon

136 pages of data — 193 diagrams, pictures and practical hints on at least 200 different uses for Smooth-On. Every progressive engineer should have this book — get your copy NOW.



SMOOTH-ON MFG. CO.,
Dept. 36, 570 Communipaw Ave.,
Jersey City, N. J.

Please send copy of the SMOOTH-ON HANDBOOK.

Name .....

Address .....

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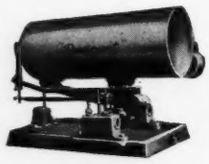
6-34 .....

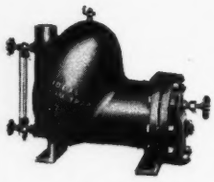
Do it with **SMOOTH-ON**

Pioneers of STEAM TRAPS

Pace Makers in Design and Construction . . .



"DETROIT" RETURN TRAP



IDEAL STEAM TRAP

TITAN and TINY BUCKET TRAP

Since 1841, in fact with the first Steam Trap invented by Joseph Nason, the name Nason has stood for leadership in the development of Steam Traps.

Ninety-two years of scientific engineering knowledge is in back of every Nason Trap. Almost a century of constant research by an efficient organization of expert engineers trained through a life-long experience to meet the demands of industries' changing needs. That is why Nason has become one of the leading manufacturers of Steam Traps today.

Nason Traps, for any application, are precision-made, with the best obtainable materials used; carefully tested for proper operation, and designed for long service under severe conditions. Scientifically correct in design, they effect large fuel savings, and their ruggedness insures low maintenance costs.

If you have any condensation problem in your plant, it will pay you to learn about the utility and economy advantages of the proper Nason Trap for your particular requirement. Further information and descriptive catalog will gladly be mailed on request.

Originators of the Steam Trap

NASON
MANUFACTURING CO.

Only complete line of traps

NASON STEAM TRAPS: "DETROIT"—Return—Vacuum—Combination—Separating; IDEAL BALL FLOAT; VESUVIUS; NASON; THERMAL; TITAN AND TINY BUCKET TRAP.

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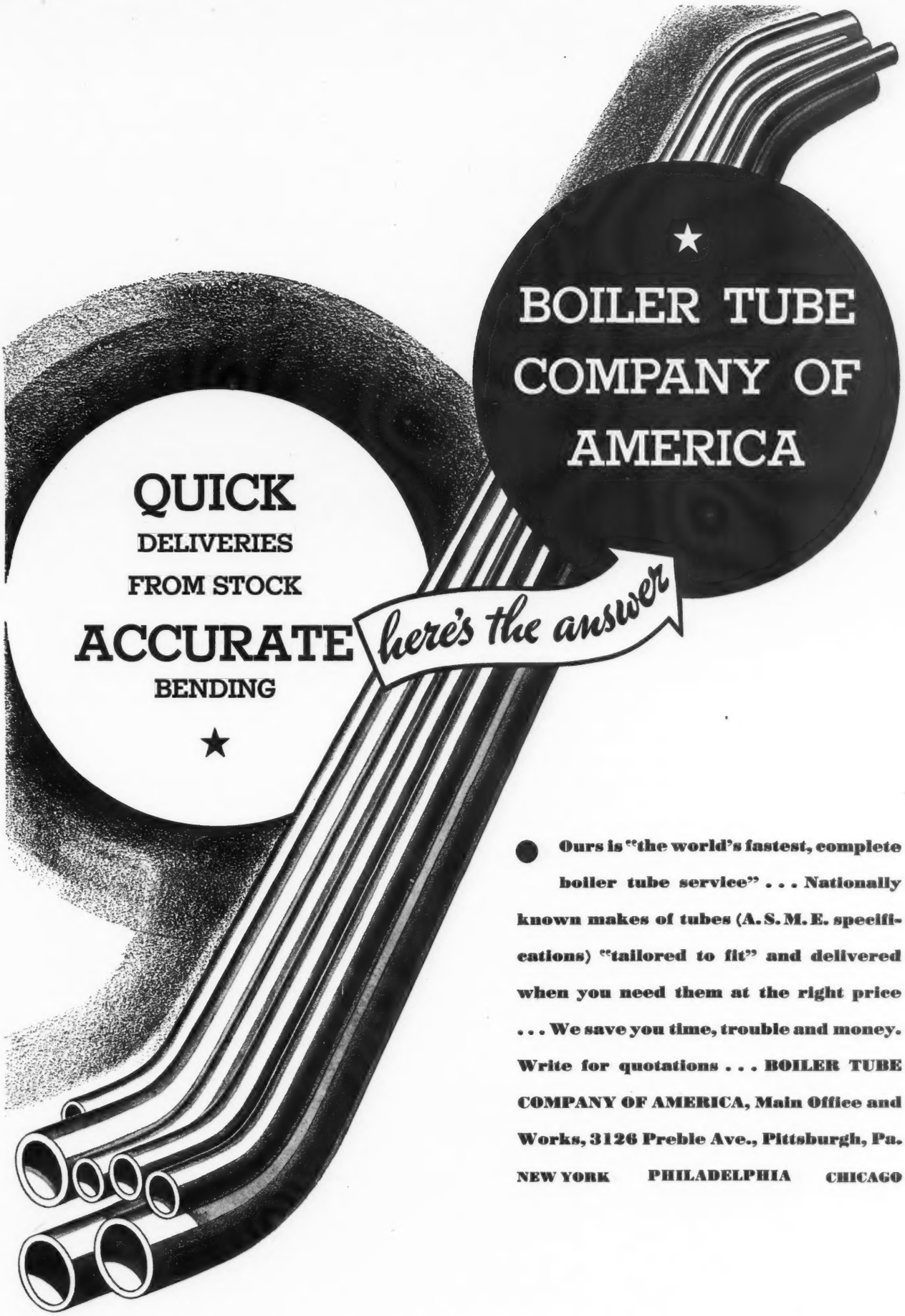
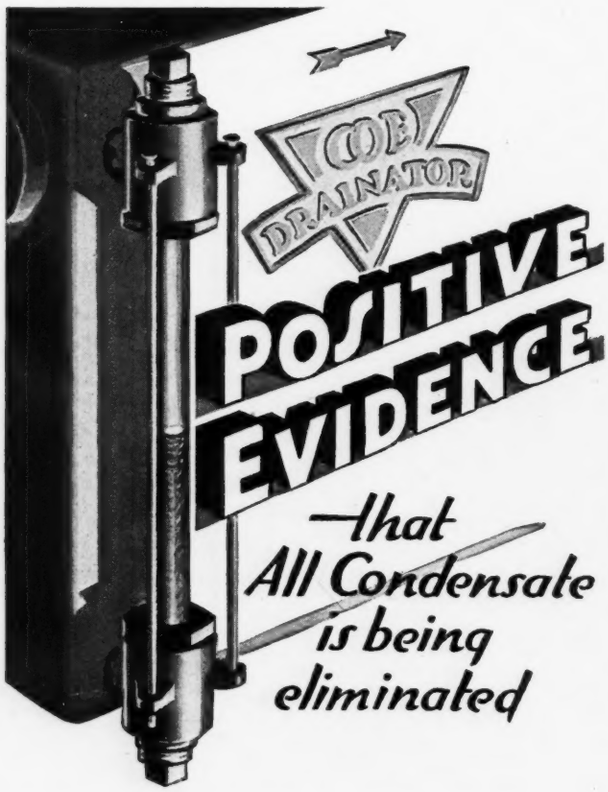
Steam Specialty Specialists since 1841

NASON STEAM SPECIALTIES: "DETROIT" Receivers; GAUGES — Quick Closing Water—All Iron Liquid Level; FEEDERS—Water—Immersed Valve—Simplex; GLUE HEATERS—Steam—gas; COCKS—Olympus Gauge—All Iron Try.



● **Ours is "the world's fastest, complete boiler tube service" . . . Nationally known makes of tubes (A. S. M. E. specifications) "tailored to fit" and delivered when you need them at the right price . . . We save you time, trouble and money. Write for quotations . . . BOILER TUBE COMPANY OF AMERICA, Main Office and Works, 3126 Preble Ave., Pittsburgh, Pa.**

NEW YORK PHILADELPHIA CHICAGO



POSITIVE EVIDENCE

that All Condensate is being eliminated

The fluctuating water level in the Drainator gauge glass gives *instant* and *positive evidence* that *all condensate* and *entrained air are being eliminated.*

To the *fuel saving* and *increased production* resulting from this distinctive operation are added; *savings* in fittings not required; *savings* in simplified operation; *savings* in the elimination of inspection costs; *savings* in maintenance expense and *savings* in the avoidance of repairs.

This revolutionary device will work modern miracles in your plant as it is doing in hundreds of others. Send the coupon for Bulletin 901.

The COE MFG. CO.
501 Bank St.
Painesville, O.

COE DRAINATOR

THE CONDENSATE DRAINER WITH NO MOVING PARTS

Send Drainator Bulletin:
Date - - - - - - - - - - - - - -
Name - - - - - - - - - - - - - -
Address - - - - - - *City* - - - - - - -

A RUN FOR YOUR MONEY

SO MANY things to look after in a big building. This tenant wants a faucet fixed and that one new bulbs. Heat and water to watch in the basement. And on top of all this the elevators. It keeps you humping to catch up. Too much for any one man.

Too much, and we suggest that you ease yourself of elevator responsibility. That you recommend Otis Elevator Maintenance to the building manager.

Under Otis Maintenance, Otis gives just as much thought to elevator care as to manufacture and installation. Keeps elevators running one hundred per cent perfectly at all times. Maintains safety. Keeps the installation in just as good condition as when it was installed.

Have a talk with your local Otis representative about Otis Maintenance. Let him show you how it will relieve you of work and worry. How it will cut expense of elevator repairs and mean good service and satisfaction to every one concerned. Otis Elevator Company — offices in all the principal cities.

MULTIPLE SPRINGS . . . .

The flexible multiple springs of Mason-Neilan regulators carry greater loads . . . permit the use of larger, more sensitive diaphragms and insure closer regulation. They provide more power, positive operation and eliminate friction and velocity effect on the valve plug. Calculated and tested for each size valve body, these multiple springs have less stress per spring and longer life.

Install the new Mason-Neilan regulators that respond smoothly and exactly to the slightest change in diaphragm control pressure . . . and obtain unvarying reduced pressures in your plant. Write for Bulletin No. 102-C.

MASON-NEILAN REGULATOR CO., 1190 ADAMS STREET, BOSTON, MASS.

Agencies in All Principal Cities

MASON-NEILAN

PRESSURE • TEMPERATURE • FLOW CONTROL

FREE SAMPLE

U·S·UNION FOR YOUR TOUGHEST SPOT!

■ Here's free proof that even the most escape-eager gases and liquids can't sneak through U. S. Unions. Mail the coupon now for sample . . . *no charge!* Try it on your toughest spot. See how the famous Four-Lock Seal says "*Halt*" and means it! Note how tight the U. S. Union stays after several make-ups. Send for your free sample now! Use the coupon below.

UNITED SUPERIOR UNION CO., INC.
Division of Mergenthaler Linotype Company
21 Ryerson Street, Brooklyn, N. Y.

GENTLEMEN:

Please send me *free* a sample U. S. Union with the Four-Lock Seal. Size.....Black or Plated.....
Line carries .....
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Company .....
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My distributor is.....

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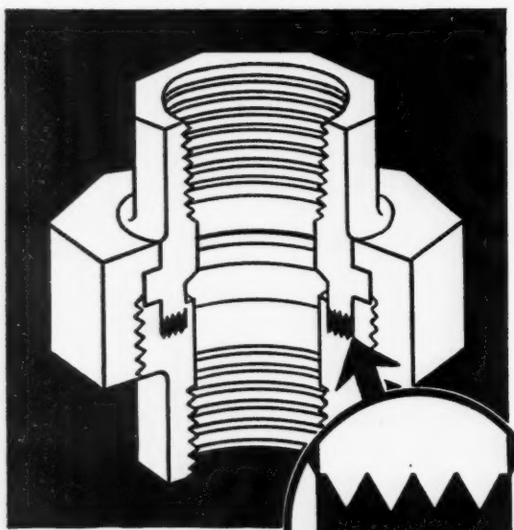


WITH·· THE FOUR-LOCK SEAL

In 1884

When the First Issue of Power was Published this Company was 11 Years Old

AS Power celebrates its 50th Anniversary, we celebrate our 61st. The American Steam Pump Company was founded in 1873 . . . . . .

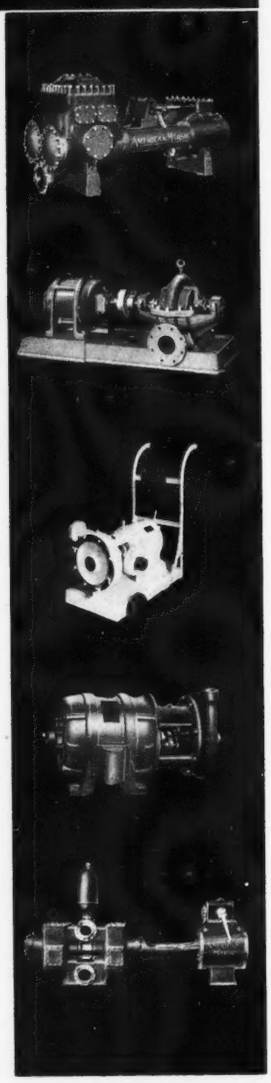
And down through all these years we have stuck to one job—BUILDING PUMPS.

Long experience with ONE product has taught us many things about that product. It is largely responsible for the modern, efficient, dependable pumps which we offer today.

Thus, when you need centrifugal or steam pumps for any service condition, we can meet your requirements with marked economy and lasting satisfaction—*because we know how.*

Your inquiry is invited.

AMERICAN STEAM PUMP COMPANY
Battle Creek, Michigan

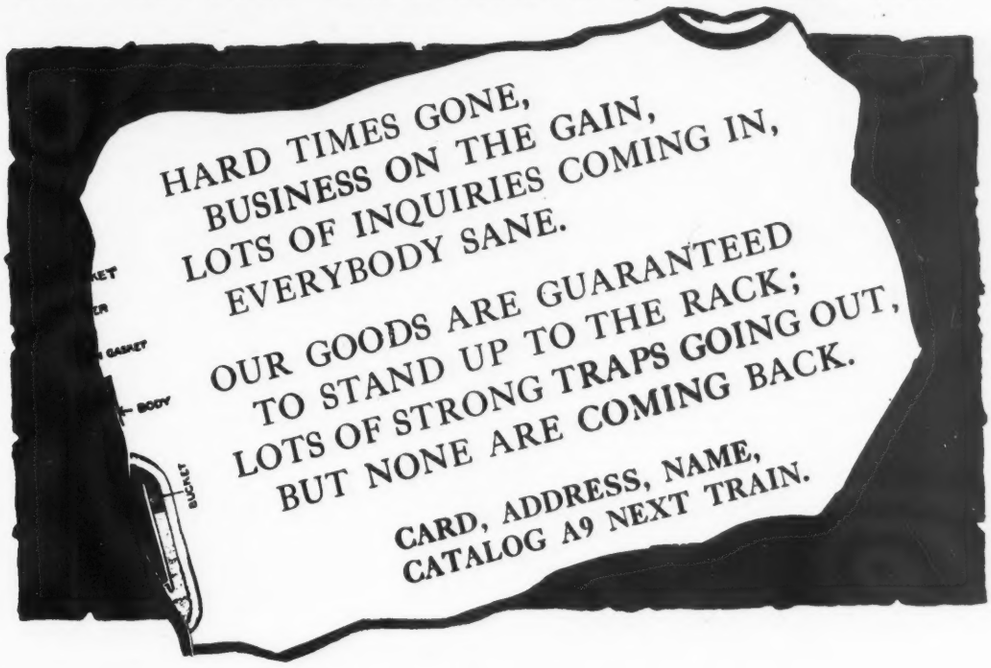


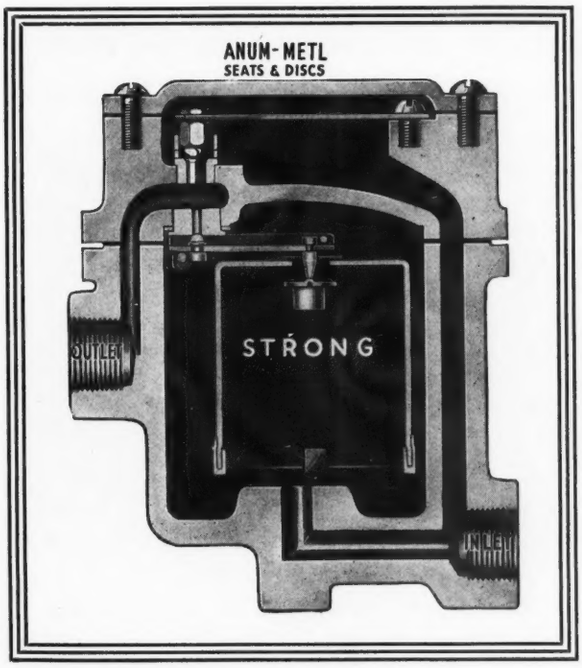
AMERICAN-MARSH PUMPS
CENTRIFUGAL AND STEAM

Following the depression of

25 YEARS AGO

Our June 1909 Advertisement in POWER said—


HARD TIMES GONE,
BUSINESS ON THE GAIN,
LOTS OF INQUIRIES COMING IN,
EVERYBODY SANE.
OUR GOODS ARE GUARANTEED
TO STAND UP TO THE RACK;
LOTS OF STRONG TRAPS GOING OUT,
BUT NONE ARE COMING BACK.
CARD, ADDRESS, NAME,
CATALOG A9 NEXT TRAIN.



TODAY, we do not have to change a word of this message, except the catalog number.

Our catalog No. 61 tells you all about Strong open and inverted bucket traps—the finest we have ever built. *Ask for it.*

The No. 70-T trap (illustrated), combines the inverted bucket and thermostatic principle and is especially suitable for unit heater, cooker and similar services requiring the very rapid elimination of air in starting.

Strong traps are available in sizes from ½-in. to 2½-in. inclusive and pressures from zero to 1800 lbs.

"ANUM-METL" VALVES AND SEATS INSURE LOW MAINTENANCE COSTS.

The Strong "patented" Anti-balancing device, found in no other make inverted bucket trap, insures intermittent operation on widely fluctuating pressure and load conditions.

The Strong, Carlisle & Hammond Co.

The Strong line of Steam Specialties includes: Steam Traps [upright and inverted bucket types], Steam and Oil Separators, Strainers, Pump Governors.

1392 West Third Street

Cleveland, Ohio

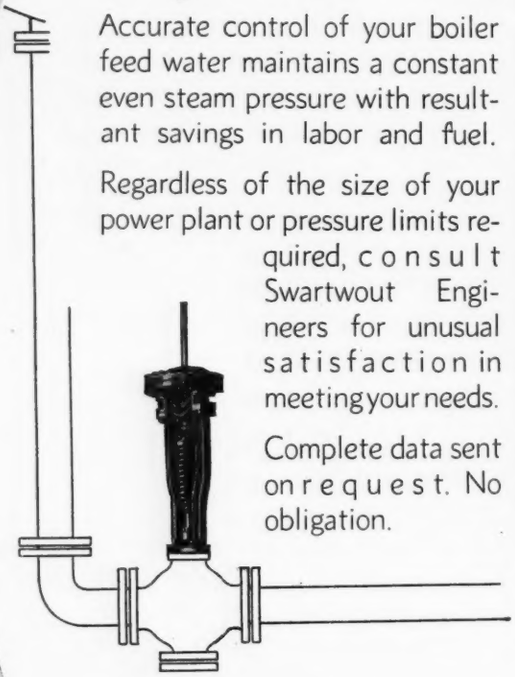
Strong Steam Specialties also include: Pressure Regulators, Reducing Valves, Non-Return Valves, Three-Way Valves, Engine Stops, "Evrtyte" Globe Valves, etc.

Put Your Feed Water Regulation Problems Up to

Accurate control of your boiler feed water maintains a constant even steam pressure with resultant savings in labor and fuel.

Regardless of the size of your power plant or pressure limits required, consult Swartwout Engineers for unusual satisfaction in meeting your needs.

Complete data sent on request. No obligation.



Swartwout

THE SWARTWOUT COMPANY

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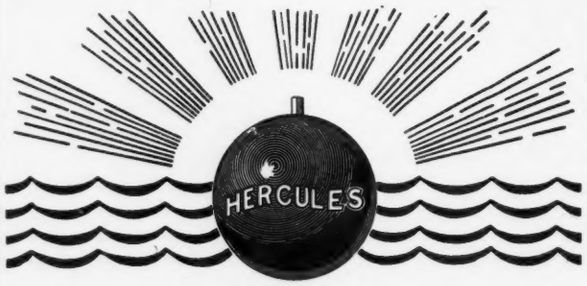
CLEVELAND, OHIO



No Danger of Collapse . . . . . .

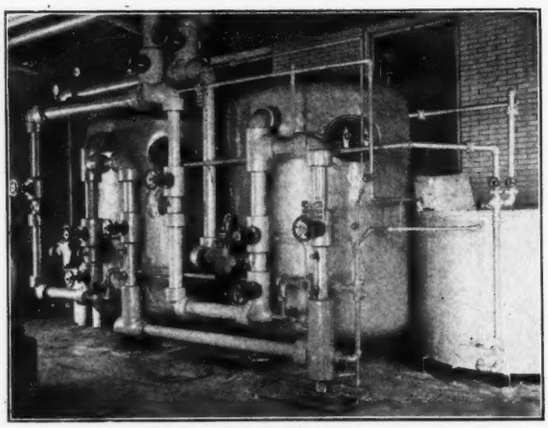
Not when HERCULES Seamless Copper Floats are used to maintain the water level in heaters, tanks, reservoirs and other appliances.

The special spinning process assures uniform thickness of metal and high mechanical strength. Every Hercules Float is guaranteed to stand up under 350 lb. working pressure and 500 deg. temperature.

Ready to ship — all standard ball shaped sizes to 10 in. inclusive. Special shapes or sizes furnished promptly on order.

HERCULES FLOAT WORKS
200 Franklin St., Springfield, Mass.

Water Softeners & Filters for every Industrial & Domestic Use



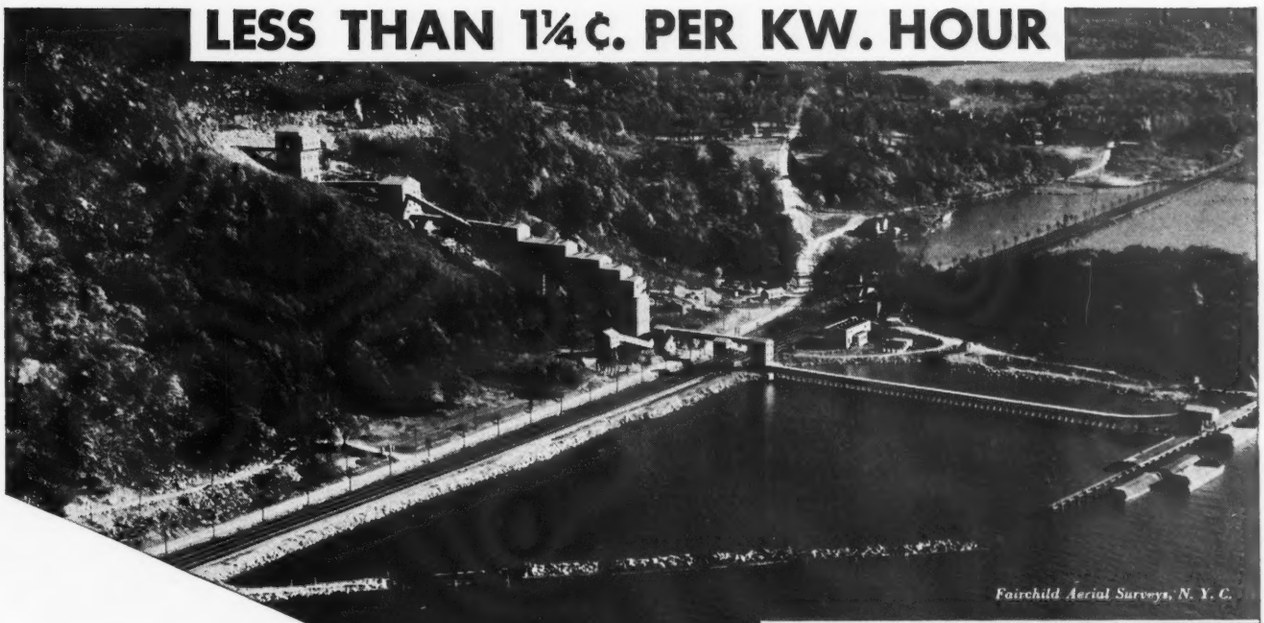
Scaife Zeolite Water Softener

Cold Process-Intermittent, Continuous and Zeolite, Hot Process, Semi-Hot Process and specially designed Water Softeners. Gravity, Pressure and Oil Removal Filters.

Write for Information and Bulletins.

WM. B. SCAIFE & SONS CO.
OAKMONT, PA.
NEW YORK PITTSBURGH CHICAGO

LESS THAN 1¼¢. PER KW. HOUR



Fairchild Aerial Surveys, N. Y. C.

Three 6-cylinder McIntosh & Seymour Solid-Injection Diesel Engines, each rated at 660 h. p. at 300 rpm. are direct connected to 500 kw. generators.

. . . this is the record of

McINTOSH & SEYMOUR

Diesel Engines at the Hudson River Stone Corporation . . . *World's Largest Crushed Stone Plant*

Power at its lowest cost for the crushing of 1,000 tons of stone per hour . . . that was the problem.

After exhaustive studies of Diesel engine cost records and comparisons with rates at which electrical energy could be purchased, Hudson River Stone Corporation's engineers chose McIntosh & Seymour engines.

Customer's partial report of the first year is as follows:

"The estimated cost to deliver energy was 1.25 cents per kw. hour. A cost well within that figure has been maintained. This cost includes fuel, interest, insurance, maintenance, operation, depreciation and overhead charges."

McIntosh & Seymour engineers will not talk in generalities about your particular power problem. They will give you facts based on experience records—facts that mean dollars and cents saved—whether for municipalities, mills, mines or ships. Put it up to us.

Bulletin No. 151 describes our newest standard engines and shows applications in various fields

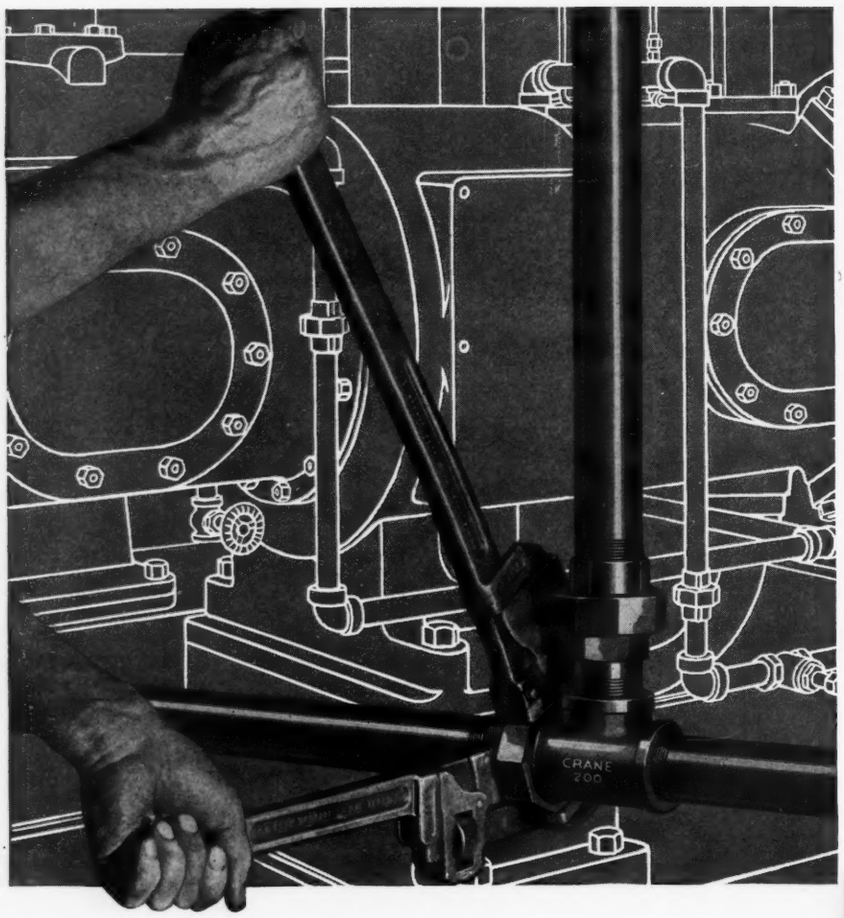
McINTOSH & SEYMOUR CORPORATION

(DIVISION OF AMERICAN LOCOMOTIVE COMPANY)

MAIN OFFICE AND WORKS, AUBURN, N. Y.

NEW YORK, N. Y., 30 Church St. | BOSTON, MASS., 88 Broad St. | CHICAGO, ILL., McCormick Bldg. | WASHINGTON, D. C., Barr Bldg.
HOUSTON, TEXAS, Esperson Bldg. | TULSA, OKLA., Philtower Bldg. | OMAHA, NEBR., Barker Bldg. | SAN FRANCISCO, CAL., Bourn Bldg.

M & S—LARGEST EXCLUSIVE MANUFACTURERS OF DIESEL ENGINES



THEY CAN "take it"

NRA Down comes the wrench . . . the entire strain of pulling the pipe line together falls on the union. Often the union must even compensate for slight misalignment.

In service, the union is subjected to the hammer of vibration and the stress of expansion and contraction.

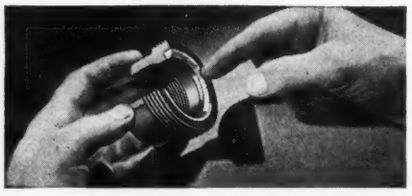
Again, it must stand the abuse of frequent assembly and disassembly.

Yes, a union must be able to "take it" . . . *and Crane unions and union fittings can!*

Crane control of metals, scientific testing and generous proportioning make these fittings particularly adaptable to use in piping lines around pumps, washers, air compressors and engines. Their permanence and dependability in service make them the choice of mining and engineering installations under all conditions.

Chamfered edges for quick pipe alignment

Constant gauging insures uniform size



A durable, tight iron-to-brass seat

CRANE

CRANE CO., GENERAL OFFICES: 836 S. MICHIGAN AVE., CHICAGO, ILL.
NEW YORK: 23 W. 44TH ST.
Branches and Sales Offices in One Hundred and Sixty Cities

Your visit to A Century of Progress Exposition should include a trip through the new Crane building.

VALVES, FITTINGS, FABRICATED PIPE, PUMPS, HEATING AND PLUMBING MATERIAL

The GREEN FUEL ECONOMIZER CO., Inc.
BEACON, NEW YORK

•

1934...1933...1932...1931

...While business has been at low ebb, Green engineers have been paving the way for opportunities that "the march of time" will undoubtedly present. Products have been improved and new developments are under way.... During the last year or two Green equipment has been installed in many plants, among them

FORSTMANN WOOLEN CO., Passaic and Garfield, N.J.
KANSAS CITY MUNICIPAL ELECTRIC LIGHT PLANT
GREAT LAKES STEEL CORP., River Rouge, Mich.
DULUTH STEAM CORPORATION, Duluth, Minn.
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GOODYEAR TIRE & RUBBER CO., Akron, Ohio
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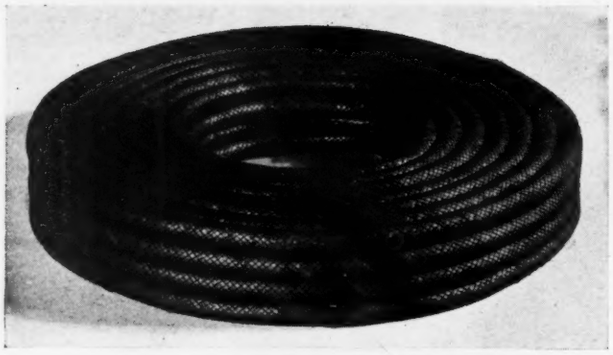
If you have a project under way involving the use of Economizers, Air Preheaters, Forced or Induced Draft Fans or Cindertraps, we should welcome an opportunity to work with you... May we send you specific information or catalogs?...The Green Fuel Economizer Co., Inc., Beacon, New York.

•

ECONOMIZERS · AIR PREHEATERS
FORCED and INDUCED DRAFT FANS
CINDERTRAPS

They will NOT *harden under heat*



LINEAR *Plastic* PACKINGS

Linear Plastics are so carefully compounded that all asbestos and metal ingredients are completely covered with lubricant and graphite. They do not harden under heat; additional packing can be added as required. Furnished in coils, spirals or loose in cans, Linear Plastic Packings help you reduce your stock; they're adaptable to all sizes of stuffing boxes. Write for descriptive circular.

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Linear Packing & Rubber Co., Inc.

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DISTRIBUTORS SAVE INDUSTRY MONEY— BUY THRU THEM

A Full Tank Always and Never Too Much

Fulton Altitude Governor

FULL flow upward till the desired level is reached, full flow downward in case of emergency, to prevent flooding—that describes the movement of water in a single line to an elevated tank where the Fulton Tank or Altitude Governor is installed. Water can flow in either direction through the same valve, depending on whether pump pressure or tank pressure is greater. The result is a constant level maintained, economy and safety alike definitely provided. Ask for full description.

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OFFER AN

ENGINEERING SERVICE

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AUTOMATIC CONTROL

BASED ON THE

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An Askania System as installed by Brassert assures constant steam pressure, uniform combustion and maximum flexibility in adjustment of boiler loads.

FOR DETAILS WRITE TO:

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CHICAGO ILLINOIS

AMERICAN AIR FILTERS for the elimination of atmospheric dust. ROTO-CLONE for control of granular or flaky process dust. AIRMAT DUST ARRESTER for collecting fibrous or fine granular process dust. Type S. C. F. FILTERS for compressor and engine protection. No matter what your dust problem, there is an AAF product to correct the condition.

2 ACTUAL PERFORMANCE RECORDS OF AMERICAN AIR FILTERS

Survey No. 1.

Oklahoma Natural Gas Company, Okmulgee, Okla. . . . Ten filters costing $964.00 installed, protect 10 gas engines . . . Comparing two five-year periods before and after filters were installed, indicates a net yearly saving of $631.00 . . . An annual return of 65.5% on the filter investment, after charging off depreciation, interest, etc.

Where *Actual Savings* ARE MADE

Valve cleaning costs . . . Valve regrinding and valve replacement . . . Shut down delays . . . Cylinder reboring and liner replacement . . . 25% to 50% of the lubricating oil required when dusty air is used . . . Many dollars otherwise lost in the wasted power and reduced capacity resulting from dust wear on cylinders and leaky valves . . . Years in the life of your compressor or engine.

Survey No. 2.

Studebaker Corporation, South Bend, Ind. During a three year period prior to the installation of American Air Filter, the maintenance and repair cost of eight air compressors was $10,005.60 ($3,335 annually). During a three year period after filters were installed a net annual saving of $2,228.11 (79.5%) was accomplished . . . An annual return of 69.9% on the filter investment.

Write for booklet, "American Air Filters in Industry".

NRA MEMBER U.S. WE DO OUR PART

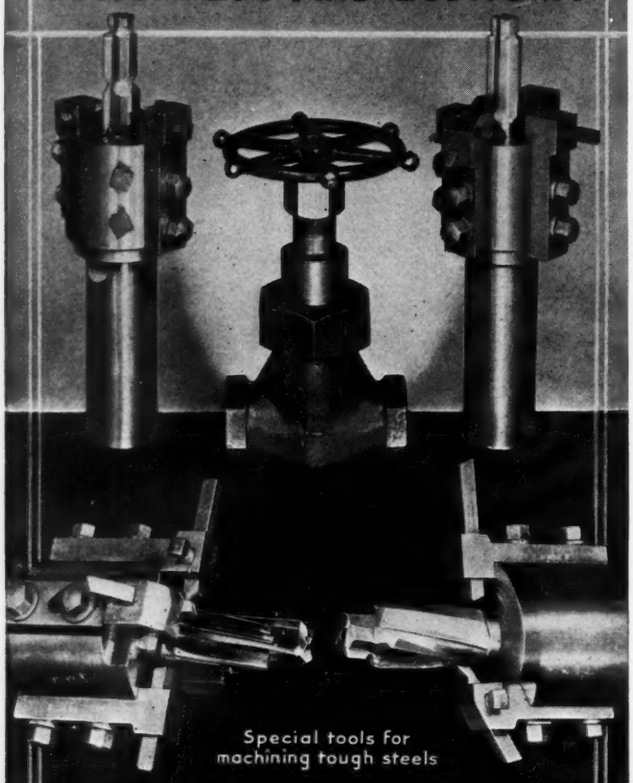
AMERICAN AIR FILTER COMPANY, *Inc.*

245 Central Avenue **Louisville, Kentucky**

In Canada, DARLING BROTHERS, LIMITED, Montreal, P. Q.

AMERICAN AIR FILTERS

STEEL EVERYWHERE FOR SAFETY AND ECONOMY



Special tools for machining tough steels

IT is full time to shift to forged steel for small valves and cast steel for larger valves. It takes steel to stand the gaff. No danger of twisting off a valve stem or fracturing a threaded joint when steel is used. And when you specify steel valves, specify Edward. Quality is controlled in the Edward shops by knowledge gained through years of experience with hard service. Good workmanship under modern production methods is based on proper tools. For use with modern, difficult-to-machine materials, special tools are designed and built in Edward's own tool shops. Thus the Edward reputation is maintained.

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For real economy buy Edward valves now

EDWARD

The Edward Valve & Manufacturing Co., Inc.
EAST CHICAGO, " " " INDIANA

VALVES

GOETZE GASKET & PACKING CO. NEW BRUNSWICK, N.J.

GASKET PROBLEMS ARE DIFFERENT TODAY . . .

GOETZE GASKETS meet any condition . . . on pipe flanges, boiler tube caps, manholes, heat exchangers, cylinder heads, superheaters, economizers and evaporators.

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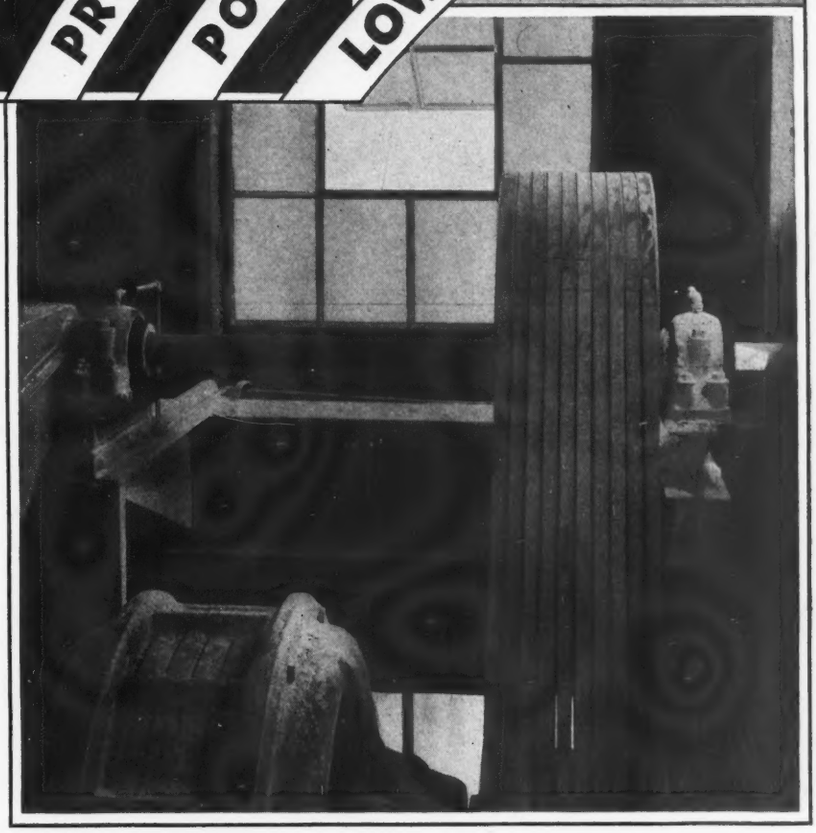
GASKET & PACKING CO.

INCORPORATED

10 ALLEN AVENUE
NEW BRUNSWICK — NEW JERSEY

YOU CAN GET ALL 3 AT *Small* COST!

PRODUCTION EFFICIENCY
POWER ECONOMY
LOW MAINTENANCE



The lazy machines in your plant can be made to deliver their full measure of production efficiency by the installation of modern drives. And at a fraction of the cost of new equipment. Under our new codes there is no place for the high-cost plant. Inefficient machinery that is expensive to operate and increases unit cost can, however, be modernized in most cases for a surprisingly small outlay.

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The type of drive used, exerts an important influence on the value of the power factor. Low power factor carries heavy penalties and results in high power costs. The selection of the right drive for each service condition, with production needs the guiding factor, will invariably result in substantial savings.

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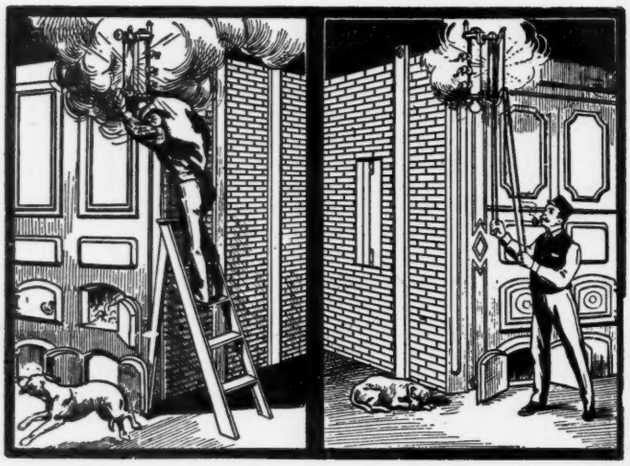
Modern Dodge engineered drives insure low maintenance. Shafts are carried in low friction Dodge-Timken bearings steel sealed against admission of dirt or leakage of lubricant. Pulleys, clutches, gears or other parts are designed for the service expected and assembled under the direction of engineers with a background of fifty years specialized experience in power transmission engineering. You can get all three of the essentials for profitable production under the N.R.A. by consulting Dodge, and thereby insuring the right drive for every job.

DODGE
MISHAWAKA
THE *Right* DRIVE FOR EVERY JOB

DODGE MANUFACTURING CORPORATION • MISHAWAKA, INDIANA

40 YEARS ON THE FIRING LINE

BEFORE HE GOT IT AFTER HE GOT IT



NOW, DON'T YOU WANT A "P.B.H." GAUGE?

Above illustration, used in "Power" by us nearly 40 years ago, was conceived and designed by Mr. Fred R. Low, himself, (then Editor of Power).

OVER a period of tremendous advance in the generation and utilization of power, The Paul B. Huyette Company, Inc., has served industry in the development, manufacture and sale of high grade steam specialties and power plant equipment.

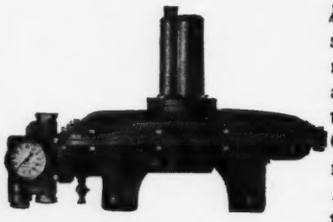
We offer you a very complete line of equipment plus the services of a trained organization, skillful engineers and specialized knowledge on correct operating methods.

Write for new catalog A-34 just off the press on Water Gauges, Gauge Cocks, Gauge Glass Protectors, Boiler Tube Cleaners, Safety Water Columns, Draft Gauges, Damper Controls, Flow Meters, CO_2 Meters, Steam Traps, etc.

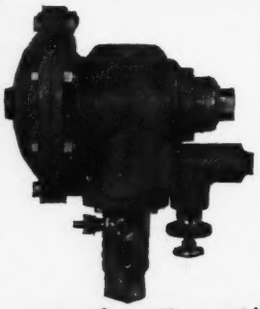
The PAUL B. HUYETTE COMPANY, Inc.
403 N. Broad St., Philadelphia, Pa.
205 E. 42nd St., New York, N. Y.

CASH STANDARD

Boiler Room Money



Real money can be saved in the boiler room. These two units are only indicative of the complete line of Cash Standard equipment for money-saving Automatic Combustion Control. The Type 90 Controller (left), actuated by furnace draft, makes surprisingly large fuel savings merely by controlling the uptake damper. Its unique constructon, its supersensitiveness, its record of successes will amaze you. And below, the Type 200 Controller, a dependable, self-contained unit, illustrates one type of steam pressure controller used on small sized boilers. But whether your plant is extremely large, or very small, there's suitable Cash Standard equipment that will make money for you. Request bulletins.



A. W. CASH COMPANY
DECATUR, ILLINOIS

When STATION OPERATORS *talk*

• TURBOIL

THEY will agree that it is THE PIONEER TURBINE OIL—used in the Largest units (160,000 k.w.)—in the Smallest units, and the Newest or Oldest types—ANY MAKE!

They will tell of TURBOIL in their systems, without discard, and with only normal makeup, for 21 years; for 17 years, or terms of 9 or 7 years—as easily at that!

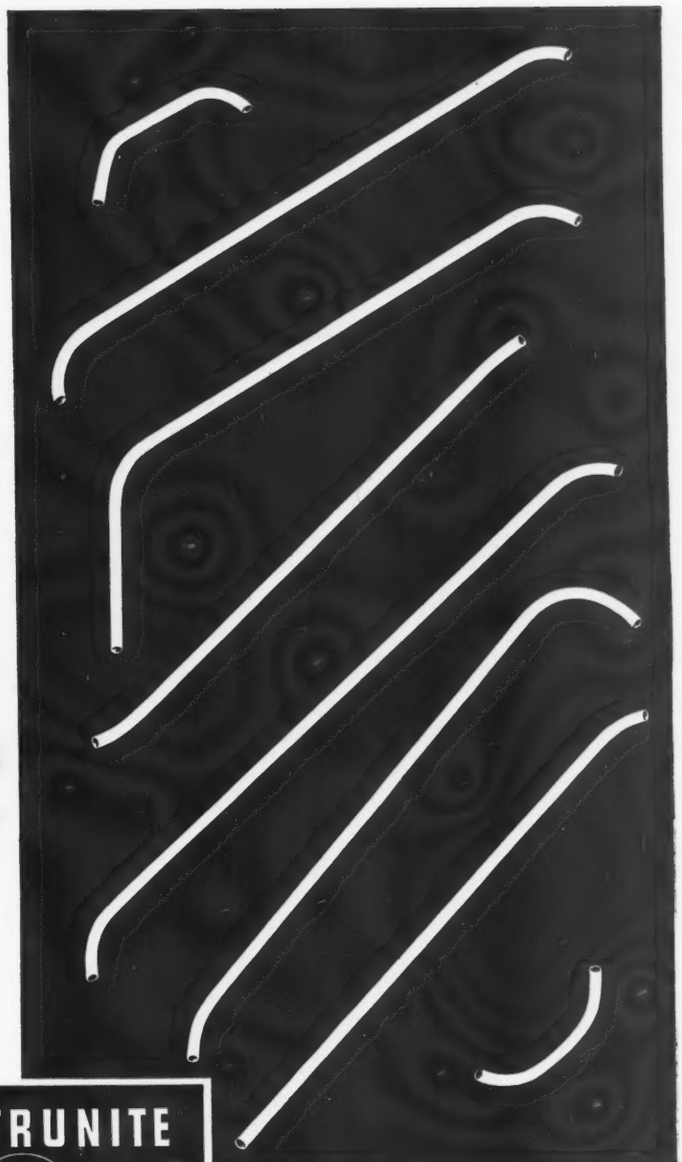
TURBOIL *is* ECONOMICAL
IT IS PROVEN....

TURBINE LUBRICATION

BORNE SCRYMSER COMPANY
17 BATTERY PLACE, NEW YORK

NOW

YOU CAN BUY ELECTRUNITE BOILER TUBES BENT TO FIT YOUR BOILER



ELECTRUNITE

STEEL & TUBES ELECTRIC WELD

BOILER TUBES

For years, users of boilers have recognized Boiler Tube Company of America, Pittsburgh, as a most reliable source of supply for bent boiler tubes. Now, through that company, you can obtain Electrunite Boiler Tubes accurately bent, guaranteed to fit every multiple drum type boiler in use today, and combining the fabricating skill of Boiler Tube Company of America and the fine qualities of this better tube.

Electrunite Boiler Tubes are ideal for bent tubes. Because they are made by the electrical resistance welding process, they are sound at the weld, perfectly round, true to gauge and so uniform in wall thickness that dangerous thinning of the wall at the outside of the bend is impossible. Every tube is full-normalized, and therefore ductile, making intricate bending much easier.

When ordering bent tubes, give the name and class letter of the boiler and number of the row for which the tubes are required. Do not hesitate to take advantage of the Engineering Service offered by Boiler Tube Company of America when tube problems arise. There is no obligation.

Write today for further information and literature.

STEEL AND TUBES, INC.

WORLD'S LARGEST PRODUCER OF ELECTRICALLY WELDED TUBING

CLEVELAND • • • OHIO

A UNIT OF REPUBLIC STEEL CORPORATION

Do profits go up your chimney in smoke? Do you *know* that the fuel you burn is the one brand best suited to the job? Are you cashing in on the economies made possible by a modernized fuel supply?

If there are any such questions in your mind, a fuel survey made by the engineers of General Coal will answer them. And it is quite likely that the answers will put actual cash in your pocket.

General Coal is playing an important part in the great activity of modernizing industry. Here — for your service — is a centralized source of supply. Here — for your selection — is a complete range of brands and sizes for every fuel requirement. Constantly, these unusual advantages are proving themselves sources of unforeseen saving to forward-looking organizations. Let a General Coal Survey, without obligation to you, make your modernizing plan complete.

GENERAL COAL COMPANY
PHILADELPHIA, PA.

BOSTON	NEW YORK	PITTSBURGH
CHARLOTTE, N. C.	CINCINNATI	BUFFALO
DETROIT		IRWIN, PA.

GENERAL COAL

DENDRON · Admiralty Coal · GENCO · PREMIX STOKER · STONEGA · RODA · DEPENDABLE ANTHRACITE · CROZER · WESTMORELAND COAL COMPANY'S CRITERION COAL

Protecting Boilers for 28 Years

IN 1906 this company began an educational campaign to awaken the power field to the seriousness of leaving boilers, connected in a battery, unprotected from bursted tubes and other internal ruptures. Since that time, hundreds of plants have bought this protection. Result, in the central stations and industrial plants of America there are today thousands of G-A Automatic Triple-Acting Non-Return Valves protecting life and property at an initial cost that is measured only in terms of the value of human life and property to the plant owner.

GOLDEN-ANDERSON
TRIPLE ACTING NON-RETURN VALVES

1. Automatically cut out the boiler the instant that a tube rupture or other internal break occurs.
2. Automatically cut off the steam flow from every boiler the instant that a steam pipe breaks.
3. Automatically equalize the pressure between all boilers.
4. Automatically cut in a boiler, making accidents due to inaccurate steam gauge impossible.
5. Positively prevent backflow of steam into a cold boiler.
6. Can be closed by hand, like ordinary stop valve, and arranged with "combination feature" to open valve like regular gate and globe valve.
7. Can be tested in service from boiler room floor.
8. Double Corliss Dash Pot that cushions in opening and closing. As they are sealed and out of current steam flow, dirt and grit cannot bind or stick valves.
9. Cannot pound, spin, stick or chatter.
10. By disconnecting pilot valve, the triple-acting style can be changed into plain non-return.

Another valve that has the popular acclaim of the field is the G-A combined throttle and automatic engine stop valve—operating 3 ways, *automatically, by hand* or *by electric switch.* The G-A line includes an automatically controlled altitude valve for standpipes, reservoirs, tanks, etc., reducing valves, check valves, float valves, etc. **A catalog of complete line will be mailed on request.**

GOLDEN-ANDERSON VALVE SPECIALTY CO.
1317 FULTON BLDG. . . . PITTSBURGH, PA.

SPEED INDICATORS that don't wear out!

THE Frahm Tachometer has *no wearing parts;* it requires no oiling. It consists of a set of accurately tuned reeds which respond by resonance to the slight vibration caused by the rotation of the machine against which it is held or on which it is mounted. It requires no belts, gears or electrical connections and costs little or nothing to install.

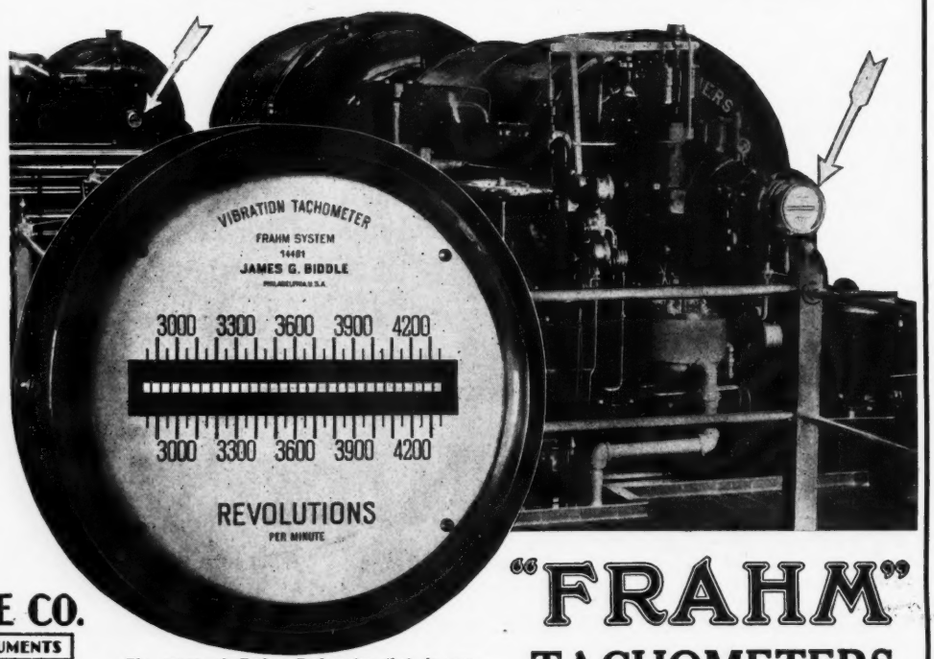
For 25 years Frahm Tachometers have been the choice of *engineers who know,* for indicating speeds of turbines, generators, motors, pumps, etc. running between 800 and 12000 r.p.m. Also they are especially suited for measuring speeds of totally enclosed machines (*except* internal combustion engines); low-torque motors such as in vacuum cleaners; and for measuring strokes per minute of pneumatic hammers and drills.

Please write for descriptive Catalog 1240-P

JAMES G. BIDDLE CO.

ELECTRICAL AND SCIENTIFIC INSTRUMENTS

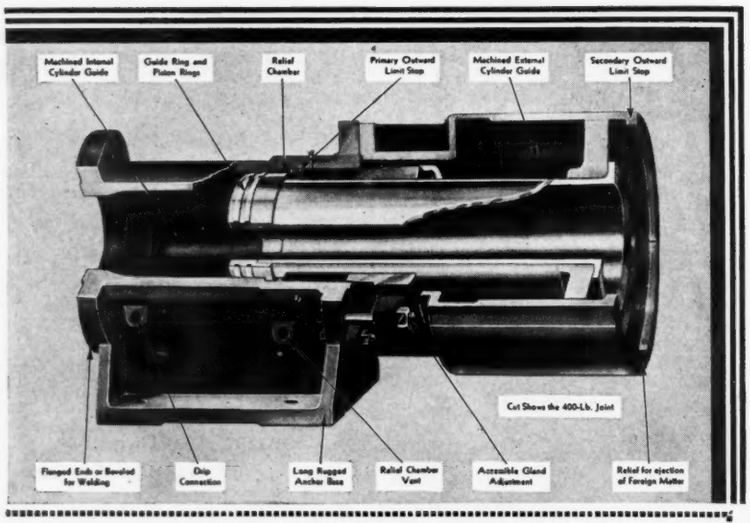
1211-13 ARCH STREET, PHILADELPHIA, PA.



The range of Frahm Tachometer that is commonly used on 3600 r.p.m. turbines. It is also available in a rectangular case.

"FRAHM" TACHOMETERS

Here's that much-talked-about


Machined Internal Cylinder Guide
Guide Ring and Piston Rings
Relief Chamber
Primary Outward Limit Stop
Machined External Cylinder Guide
Secondary Outward Limit Stop
Cut Shows the 400-Lb. Joint
Flanged Ends or Beveled for Welding
Drip Connection
Long Rugged Anchor Base
Relief Chamber Vent
Accessible Gland Adjustment
Relief for ejection of Foreign Matter

AMERICAN DISTRICT STEAM COMPANY

GENERAL OFFICES AND WORKS

NORTH TONAWANDA, N.Y.

Please send us complete literature on the Piston-Ring Expansion Joint.

Company .....

Attention .....

Address P634

ADSCO

PISTON-RING EXPANSION JOINT

that can be repacked under full operating pressure!

. . . The Pittsburgh Testing Laboratory attests to this fact.

No more shutdowns for repacking. No tying up of service. That's what ADSCO has accomplished by adapting the piston ring principle to expansion joints.

ADSCO PISTON-RING EXPANSION JOINTS not only make it possible to completely unpack and repack without a minute's interruption of service, but materially prolong packing life.

How much does this assured sustained operation of your steam lines mean to you?

The coupon will bring you the new bulletin.

OVER FIFTY YEARS IN BUSINESS

LEADERSHIP

attested by 45 years' service

YOUR SAFEST GUIDE

in the years ahead

IT is a far cry indeed from those early days of the power industry up to the present time which inaugurates the Fiftieth Anniversary of POWER.

Yet coincident with the marvelous growth in generation, transmission and utilization which has been achieved over the intervening years—a growth of glorious accomplishment splendidly commemorated in this issue of POWER—is the notable record of service which BRISTOL'S Recording Instruments have contributed to the progress of the power industry. BRISTOL'S leadership, attested by forty-five years' endorsement, is your safest guide in the years ahead.

THE ELECTRICAL WORLD. 301

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

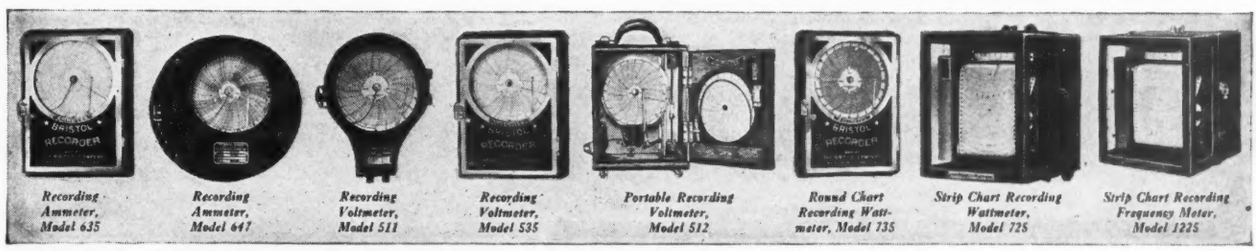
FIGS. 1 AND 2.—RECORDING VOLTMETER.

(Right) Reproduction of page 301 of the Electrical World for Oct. 14, 1893, describing BRISTOL'S "Recording Voltmeter for Alternating and Direct Current." As the article points out, this recording voltmeter meets the "demand in electric light and power stations for a voltmeter which would make a continuous record day and night of all changes of voltage." It is "simple in construction and sensitive and accurate in its operation." How true, still, today of BRISTOL'S perfected Recorders of precision accuracy!

BRISTOL'S Recording Electrical Instruments include voltmeters, millivoltmeters, ammeters, shunt ammeters, wattmeters and frequency meters, in original form and rectangular models, for surface or flush mounting or for portable service, with round or strip charts.

THE BRISTOL COMPANY, WATERBURY, CONN.

Branch Offices: Akron, Birmingham, Boston, Chicago, Denver, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco



Recording Ammeter, Model 635 — *Recording Ammeter, Model 647* — *Recording Voltmeter, Model 511* — *Recording Voltmeter, Model 535* — *Portable Recording Voltmeter, Model 512* — *Round Chart Recording Wattmeter, Model 735* — *Strip Chart Recording Wattmeter, Model 725* — *Strip Chart Recording Frequency Meter, Model 1225*

TRADE MARK

BRISTOL'S

REG. U. S. PAT. OFF.

PIONEERS IN PROCESS CONTROL SINCE 1889

More than 2,000,000 Tons of Coal Crushed Without One Cent For Repairs!

It sounds unbelievable—but American Rolling Ring Crushers, equipped with Timken Bearings, have exceeded this record in actual service. The flexibility of the AMERICAN Rolling Ring Crushing Principle, together with correct design and rugged cast steel construction, assures lowest cost per ton for both power and maintenance.

Even more important, however, to Power Plant Engineers, is the increased operating efficiency assured through correct sizing of coal for either stoker use or pulverized coal burning. Hundreds of installations have shown that this better sizing cuts total fuel costs from 2½ to 8%.

These Reversible Manganese Steel Shredder and Scraper Rings are a patented feature found only in American Rolling Ring Crushers. They split the coal instead of crushing it, which assures a uniform size of crushed coal. An adjustable grinding plate makes it possible to obtain properly sized coal for either stoker or pulverizer use. These crushers can be adjusted to make a maximum or minimum amount of fines.

We will gladly send you complete information on American Rolling Ring Crushers. *Write today.*

ORIGINATORS OF THE ROLLING RING CRUSHER PRINCIPLE

AMERICAN PULVERIZER CO

1249 MACKLIND AVE., ST. LOUIS, MISSOURI

10 Important Features

in the new Kennedy Heavy Standard Bronze Globe Valve

1. Union bonnet ring and packing nut made of malleable iron for extra strength; cadmium plated for permanent protection against rusting
2. Bronze-to-bronze true union joint between bonnet and body
3. Special machined low friction contact surface between stem head and disc holder for easy operation
4. Raised seat in body is unusually high for longer disc life
5. Slip-on disc holder has four guide prongs to prevent binding—locks in wide-open position but releases at a half-turn of the stem
6. Stem has large number of heavy contact threads to reduce wear
7. Conical joint between stem and bonnet permits packing under pressure
8. Stuffing box is exceptionally deep with self-lubricating molded packing and long gland follower
9. Complete interchangeability of operating parts in globe and angle valves of same size
10. Non-heating comfortable-grip handwheel

Order some of these valves from your distributor and try them out at the first opportunity. You will find their easy operation, low maintenance expense and long life make them the best possible val e investment.

Kennedy Fig. 89

With Composition Renewable Disc for 150-lb. Steam Press. 250-lb. Water Press.

THE KENNEDY VALVE MFG. CO., ELMIRA, N. Y.

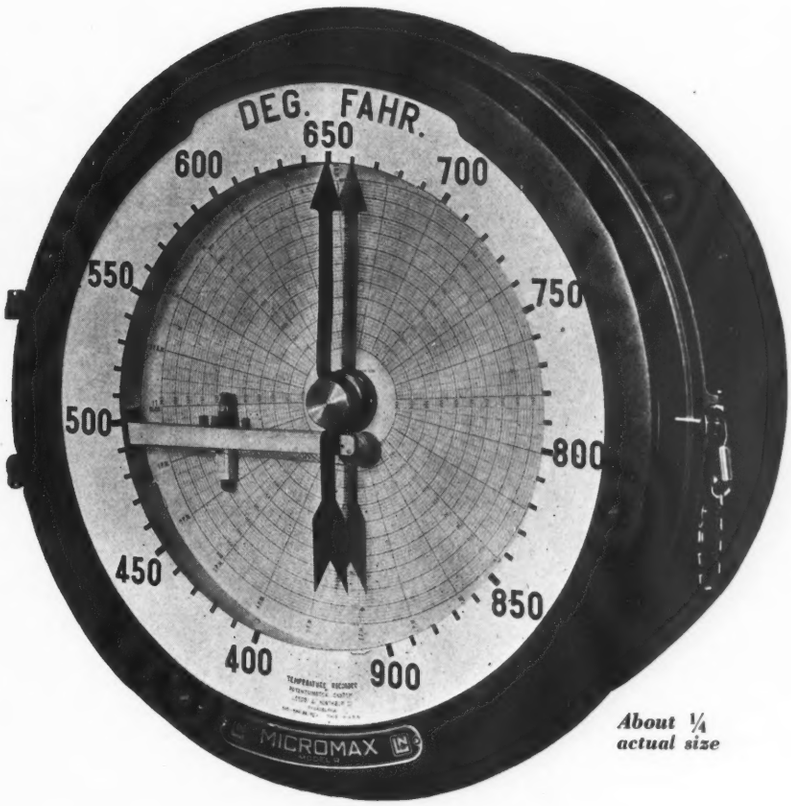
KENNEDY

VALVES-PIPE FITTINGS-FIRE HYDRANTS

NEW ECONOMIES

For 1934

Or Greater Economies



About ¼ actual size

IN STEAM GENERATION

Combustion Control
Furnace Temperature
Boiler Pass Gas Temperature
Flue Gas Temperature
Flue Gas Analysis
Smoke Density
Preheater Air Temperature
Economizer Water Temperature
Feed Water Temperature
Boiler Steam Temperature
Superheater Steam Temperature
Condenser Steam Temperature
Cooling Water Temperature
Condensate Temperature
Condensate Purity
Make-Up pH (Acidity & Alkalinity)
Make-Up Conductivity
Boiler Water Concentration

IN HYDRO POWER GENERATION

Gate Position
Water Level
Dam Temperatures
Turbine Bearing or Oil Temperatures
Turbine Speed

IN DIESEL, GASOLINE & GAS POWER GENERATION

Engine Bearing or Oil Temperatures
Engine Cooling Water Temperatures
Engine Exhaust Analysis
Engine Exhaust Temperatures
Engine Speed
Gas Pressure

IN STEAM DISTRIBUTION

Steam Temperature
Turbine Steam and Water Temperature
Turbine Bearing or Oil Temperature
Turbine Speed

IN ELECTRIC POWER GENERATION

Turbine Steam & Water Temperature
Turbine Bearing or Oil Temperature
Turbine Speed
Generator Stator Temperature
Generator Rotor Temperature
Generator Cooling Air or Gas Temperature
Generator Air-Cooler Water Temperature
Generator Bearing or Oil Temperature
Generator Load
Generator Frequency & Load Control
Station Load

IN ELECTRIC POWER DISTRIBUTION

Station Load
System Load
Frequency
Frequency Changer Input-Output
Frequency Changer Temperature
Synchronous Condenser Temperature
Transformer Temperature
Cable & Cable Duct Temperature

IN LABORATORIES & MAINTENANCE

Heat Value of Fuel
Instrument Standardizing
Instrument Transformer Testing
Meter Testing
Dielectric Loss
Insulation Resistance
Conductor Resistance (Conductivity)
Conductor Faults

Through Modern L&N Instruments and Controls

Because of new designs and redesigns in L&N instruments and controls, new and greater economies are today within easy reach of power plant operators.

The time during which preventable losses occur has been shortened. Instrument-response has been quickened. Big indicator dials are readable at unusual distances. Lights, bells and sirens warn when limits are exceeded. Readings are telemetered from building to building, plant to plant, system to system, simply and reliably.

Readability of instruments has been magnified so that more accurate analyses of conditions are possible. Automatic controls for many quantities are engineered exactly to individual needs.

At the Left Are Representative Applications

LEEDS & NORTHRUP COMPANY
4901 STENTON AVENUE PHILADELPHIA, PA.

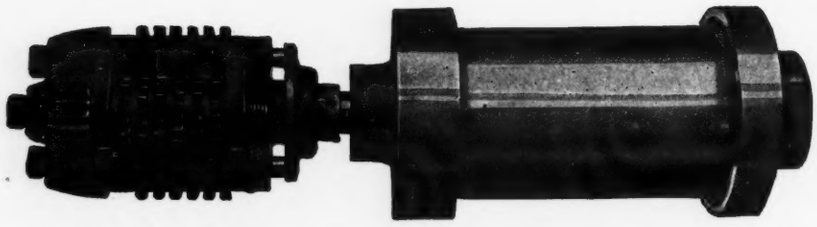
LEEDS & NORTHRUP

ELECTRICAL INDICATING and RECORDING INSTRUMENTS and CONTROL APPARATUS for SCIENCE and INDUSTRY

T-338

DIRTY TUBES WASTE MONEY

Clean tubes insure maximum exchange of heat . . . save both fuel and labor



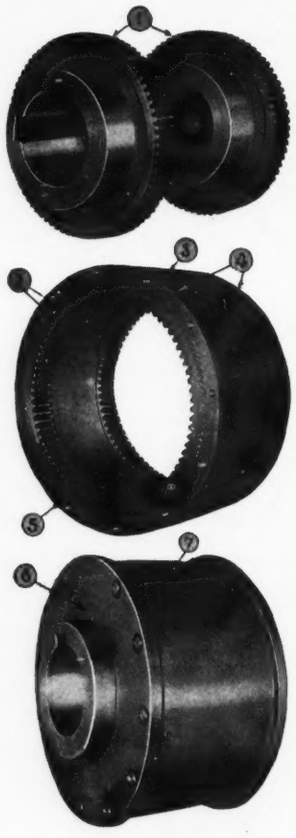
Roto Heavy Duty Type for 3¼-4" Straight Tubes
Featuring the Roto Swing Frame Head

You can have perfectly clean tubes, at low cost, with Roto Tube Cleaners —in heat exchangers of all kinds, boilers, economizers, stills, etc.

Catalog describing complete line of Roto Cleaners for all purposes sent on request.

THE ROTO COMPANY
SUSSEX AVE. AND NEWARK ST., NEWARK, N. J.

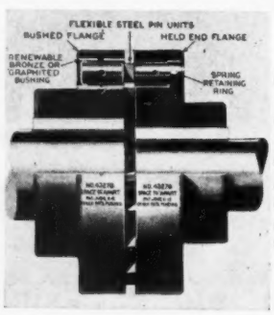
A New and Better HEAVY-DUTY COUPLING



Power Plant Engineers, especially those who have used our popular Francke Flexible Coupling, will be glad to know that we are now furnishing a new gear-type coupling for heavy-duty service which affords important advantages over all gear-type couplings heretofore available.

WALDRON TORQUE RING COUPLINGS

employ the new patented principle of *Quadruple Engagement.* When the connected shafts become misaligned there are *four* points within the coupling at which relative movements can freely take place. Each torque ring (2) can tilt and can slide endwise with respect to its hub member (1) while the torque rings (and hubs) can also tilt and move endwise within the single-piece cover sleeve (3).



For drives requiring resiliency we still recommend Francke Couplings, with flexible steel pin units to cushion shocks.

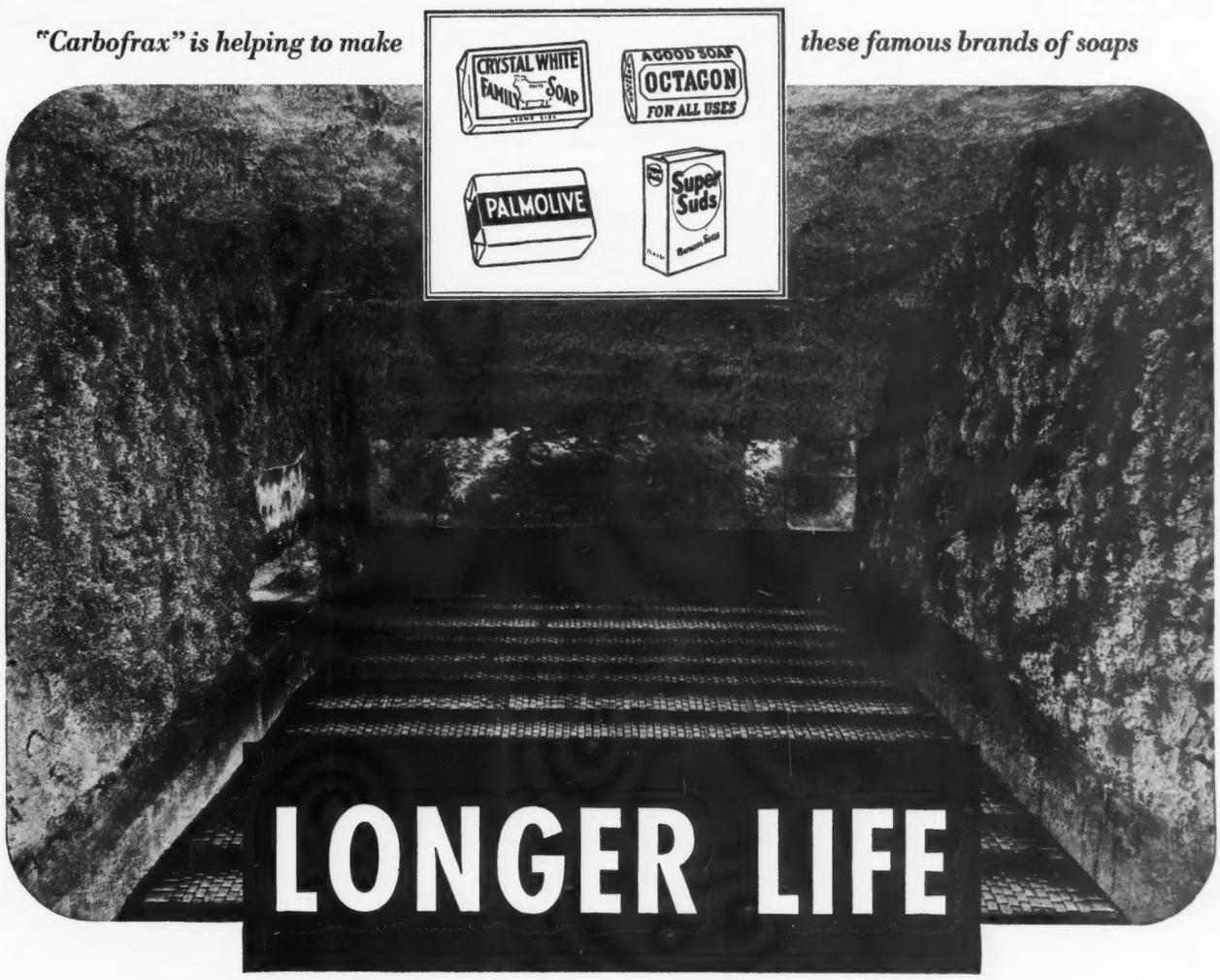
When running, oil under centrifugal pressure fills the space between the cooperating gear teeth. Therefore, these Waldron Torque Ring Couplings have an indefinitely long life even when operated continuously within their rated misalignment capacity.

Severe tests under extremely difficult conditions have proved the value of Waldron Torque Ring Couplings for every type of heavy duty service. Now available in 12 standard sizes, for shaft diameters ranging from 1¼ in. to 12 in. Bulletin on request.

SMITH & SERRELL
Coupling Specialists Since 1912

1 Halsey St., Newark, N. J.

"Carbofrax" is helping to make *these famous brands of soaps*



"CARBOFRAX" DOUBLES RECORD OF PREVIOUS LINING

In the plant of Colgate-Palm Olive Peet Company, Jersey City, N. J., "Carbofrax" lined boiler walls gave over double the life of the water box construction used previously.

This remarkable fact was proven after a test installation in one of their 344 H. P. water tube boilers burning No. 3 barley coal, operated with chain grate stoker at an average rating of 150%.

And even after four years *the "Carbofrax" Brick were still in excellent condition.*

Naturally this company equipped other boilers on their line with "Carbofrax." The resulting economies in all boilers was pretty much the same. All installations are still going strong.

"CARBOFRAX"

REG. U. S. PAT. OFF.

The Carborundum Brand Silicon Carbide Refractory

BRICK • TILE • MUFFLES • HEARTHS • CEMENT

THE CARBORUNDUM COMPANY (Refractory Division) Perth Amboy, N. J. District Sales Branches: Boston, Chicago, Cleveland, Detroit, Philadelphia, Pittsburgh. Agents: L. F. McConnell, Birmingham, Ala.; Christy Firebrick Company, St. Louis; Harrison & Company, Salt Lake City, Utah; Pacific Abrasive Supply Co., Los Angeles, San Francisco, Seattle; Denver Fireclay Co., El Paso, Texas; Williams and Wilson, Ltd., Montreal-Toronto, Canada. (Carborundum and Carbofrax are registered trade marks of The Carborundum Company.)

Putting the Pull into Belts

STEPHENSON BAR BELT DRESSING
. . . on the job since 1888

To prevent slipping belts . . . for 46 years this standard treatment has had the endorsement of power men in all parts of the world. It is a modern product, too, for in addition to a higher power delivery . . . Stephenson's adds years to the life of the belt . . . it penetrates the pores, making the belt soft, pliable and strong.

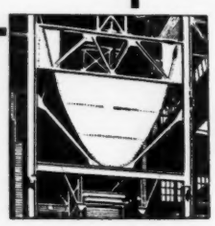
There are three types which can be obtained from jobbers everywhere. The Red Label for leather belting, the Green Label for rubber, canvas and balata belting, and the Brown Label for rope. A large sample for trial purposes will convince you of how Stephenson's puts the pull into belts.

Stephenson Manufacturing Co.
Albany, N. Y.

Of proved efficiency *by the test of the years!*

PROTECTS
STACKS—TANKS
STANDPIPES
BOILER FRONTS
BREECHINGS
COOLING TOWERS
STEEL PIPES
REFRIGERATING PLANTS
ACID ROOMS
and every other type of equipment

HERMASTIC ENAMEL
for lining coal bunkers



BITUMASTIC
REG. U. S. PAT. OFF.

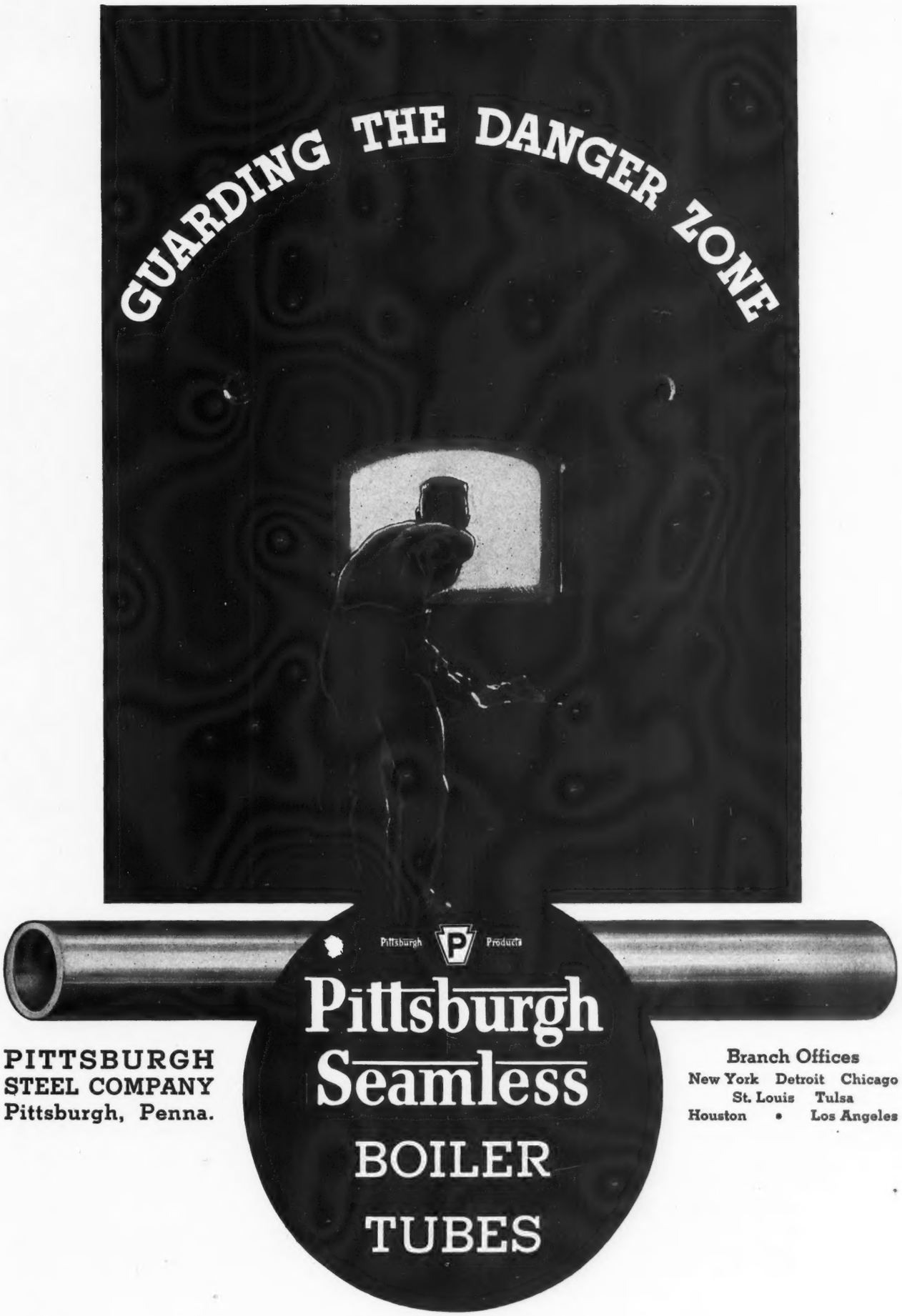
HEAT, ACID AND MOISTURE RESISTING

A brilliant, black, quick-drying, heat-resisting bituminous paint, impervious to moisture and chemical fumes. Applied by brush or spray.

A mere list of the structures and notable equipment protected by BITUMASTIC would read like a history of the development of the modern power plant. This protection will still be effective for years into the future.

Send for a Sample Can

WAILES DOVE-HERMISTON CORPORATION
17 Battery Place, New York, N. Y.



PITTSBURGH
STEEL COMPANY
Pittsburgh, Penna.

Branch Offices
New York Detroit Chicago
St. Louis Tulsa
Houston • Los Angeles

DIRECT STEAM SEPARATION

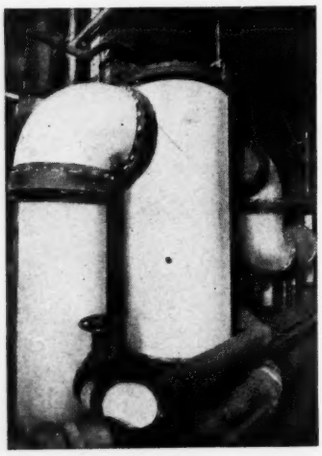
Time	Steam Gauge Corrected	Temp. of Steam Deg. F	Temp. in Calor. Before A Deg. F.	Temp. in Calor. After A Deg. F	Back Pressure Calor. Inches	Quality of Steam Before	Quality of Steam After
Average 1st Day	84.2	326.5	264	282.5	1⅛	98875	99.75
Average 2nd Day	81.7	324.7	250.05	274.7	1⅛	98.35	99.55
Average 3rd Day	90.2	330.9	259	291.3	1⅛	98.99	99.75

Barometer 29.03 Boiling Temperature 212.3
Separator drip per hour at bottom averaged about 178 pounds

99.5% DRY

...SERVICE PROVED *in thousands of plants for over 40 years...*

Test of DIRECT SEPARATOR, conducted by Prof. R. C. Carpenter of Cornell University at Eliza Furnace, Jones & Laughlin Steel Co., Pittsburgh, Pa.



A modern 20" Horizontal O i l Separator.

More than 17,000 DIRECT SEPARATORS have been installed since Prof. John E. Sweet pioneered his invention over forty years ago.

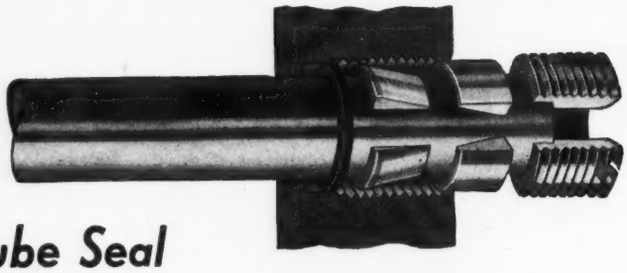
As further proof of acceptance and satisfaction, 50% of these installations have been on duplicate or repeat orders.

DIRECT SEPARATORS are built today in many standard types as well as special designs for special conditions. Every installation is guaranteed to deliver 99.5% dry steam or better and to clean exhaust steam so thoroughly that less than 1/3 grain of oil will be contained in each gallon of condensate.

Our engineering service is always at your disposal.

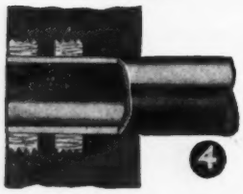
THE DIRECT SEPARATOR COMPANY
Syracuse, New York

"John Crane" Fittings and Metallic Packing



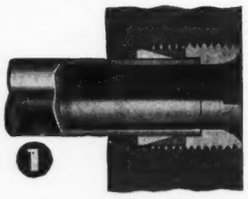
The Perfect Condenser Tube Seal

Outflow End



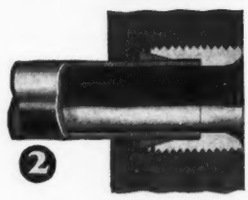
"John Crane" Fittings on the inflow end and "John Crane" Metallic Packing on the outflow end for tube fixation in Surface Condensers or heat transfer equipment is the new way to efficient operation and economical maintenance. "John Crane" Fittings compress radially against the tube under ferrule pressure—bonding the tube to the tube sheet in a perfect seal. Rolling, expanding or annealing tubes is no longer necessary. "John Crane" Fittings seal perfectly under temperature changes without deforming the tube, and permit assembly or tube inspection in one-fifth the time required by other methods.

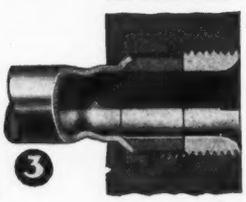
Inflow End



"John Crane" Fittings are especially recommended for use on the inflow end. Standard "John Crane" Metallic Condenser Packing is used on the outflow end to provide for expansion and contraction. "John Crane" Metallic Packing has long been standard in industrial and marine service, as shown in figure 4.

"John Crane" Fittings are adaptable to every tube sheet condition as shown in figures 1, 2 and 3. They are made of Admiralty Metal, Cupro-Nickel or the same specifications as the tube material and may be used over again with maximum efficiency. Tubes are easily removed for inspection and reinstalled without dressing.





OUR SERVICE ENGINEERS WILL GLADLY DEMONSTRATE WORKING MODELS.

CRANE PACKING COMPANY
1801 CUYLER AVE., CHICAGO

Philadelphia—108 Walnut Street
Detroit—1720 Twelfth Street
New Orleans—524 Poydras Street
San Francisco—112 Ninth St.
New York—75 West Street
Pittsburgh—717 Liberty Ave.
St. Louis—4120 Shaw Blvd.
Seattle—Pier 2
Los Angeles—350 S. Anderson St.
Baltimore—306 Canton House

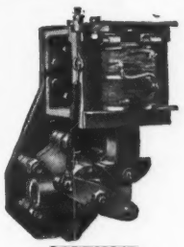
(Write the office nearest you)

NICHOLSON THREE *and* FOURWAY VALVES

Lever, Foot and Solenoid Operated

LEVER

FOR operating air, steam, oil or water single and double acting cylinders on all kinds of equipment. Also made in straight-thru and special purpose types.



SOLENOID

Flat disc type, that operates easily and holds tight. For all pressures up to 300 lbs. Write for Bulletins No. 1131, 1132 and 1032 describing types shown.

FOOT

W. H. NICHOLSON & CO., 125 Oregon St., Wilkes-Barre, Pa.

A PACKING FOR EVERY SERVICE

Johns-Manville PACKINGS

Write for COMPLETE J-M PACKING CATALOGUE

JOHNS-MANVILLE, 22 EAST 40th STREET, NEW YORK CITY

BERNITZ SUPER BLOCKS

*MADE OF "CARBOFRAX"

Avoid many sources of furnace setting and stoker UPKEEP!

1. Clinker-free walls avoid many fuel bed conditions which often cause more than one-half of stoker maintenance.
2. Cleaning time may be shortened to allow practically continuous efficient furnace operation.
3. Costly setting maintenance is avoided inasmuch as BERNITZ "Carbofrax" AIR-COOLED FURNACE LININGS last much longer than first quality firebrick —6 to 8 times is not uncommon.
4. A BERNITZ engineer will be glad to explain how this simple self-supporting system can be installed in your settings to show a high return from a moderate investment.

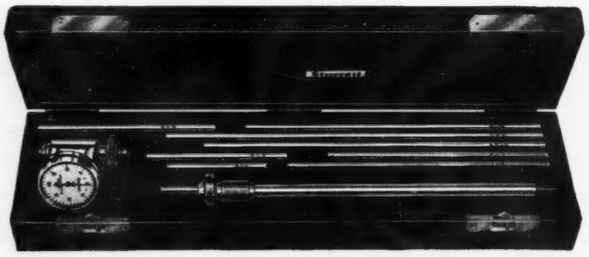
* Carbofrax is the registered trade mark for silicon carbide refractories made by The Carborundum Co.

BERNITZ FURNACE APPLIANCE COMPANY

Home Office—89 Broad St., Boston, Mass.

NEW STARRETT DIAL GAGE

Measures Crank Shaft Distortion and Engine Frame Strain



Starrett Dial Gage No. 696 checks bearing alignment or undue shaft deflection without dismantling the engine. Valuable for Diesel and all other types of engines and compressors, also as strain gage on engine frames while engine is operating. Makes thousandths of an inch readings quickly and accurately.

Price with leather case and 10 extension rods for range of 2¼ to 18 inches—$24.50. Write for interesting descriptive Circular P.

THE L. S. STARRETT CO., ATHOL, MASSACHUSETTS

Incomparable for centrifugal pumps.

ALLPAX

THE PACKING THAT "PACKS ALL"

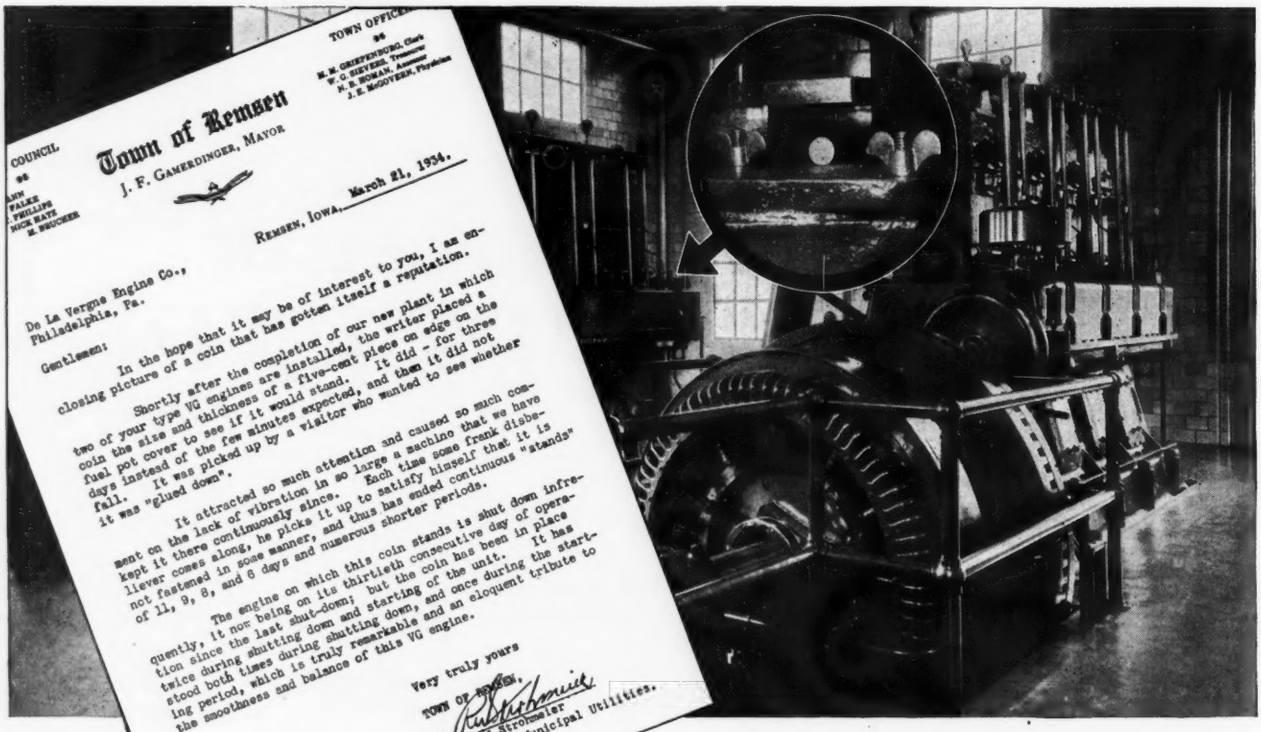
Reg. U. S. Pat. Off.

The Stuff for Stuffing Boxes

Engineers who have once tried ALLPAX—the universal packing—are enthusiastic over its time and labor saving qualities as well as its efficiency. They don't have to bother with so many styles and sizes—ALLPAX can be used for any fluid, on any apparatus and in all size stuffing boxes. When it wears, simply back off the gland and add more, leaving the old packing in. It wears longer without hardening, reduces friction and never scores the rod. Now made in square cross-section to better fit the stuffing box.

A postcard will bring you interesting information. Write today.

THE ALLPAX CO., INC.
Mamaroneck, N. Y.
DISTRIBUTORS EVERYWHERE



COUNCIL
[illegible]
PHELPS
NICK MATT
M. BRUCKER

TOWN OFFICERS
[illegible]
H. W. GRIEFENHAGEN, Clerk
W. G. SIEVERS, Treasurer
N. A. ROMAN, Assessor
J. F. McGOVERN, Physician

Town of Remsen
J. F. GAMERDINGER, MAYOR

REMSEN, IOWA, March 21, 1934.

De La Vergne Engine Co.,
Philadelphia, Pa.

Gentlemen:

In the hope that it may be of interest to you, I am enclosing picture of a coin that has gotten itself a reputation.

Shortly after the completion of our new plant in which two of your type VG engines are installed, the writer placed a coin the size and thickness of a five-cent piece on edge on the fuel pot cover to see if it would stand. It did - for three days instead of the few minutes expected, and then it did not fall. It was picked up by a visitor who wanted to see whether it was "glued down".

It attracted so much attention and caused so much comment on the lack of vibration in so large a machine that we have kept it there continuously since. Each time some frank disbeliever comes along, he picks it up to satisfy himself that it is not fastened in some manner, and thus has ended continuous "stands" of 11, 9, 8, and 6 days and numerous shorter periods.

The engine on which this coin stands is shut down infrequently, it not being on its thirtieth consecutive day of operation since the last shut-down; but the coin has been in place twice during shutting down and starting of the unit. It has stood both times during shutting down, and once during the starting period, which is truly remarkable and an eloquent tribute to the smoothness and balance of this VG engine.

Very truly yours
TOWN OF REMSEN,
BY R. W. Stromeier
R. W. Stromeier
Sup't., Municipal Utilities.

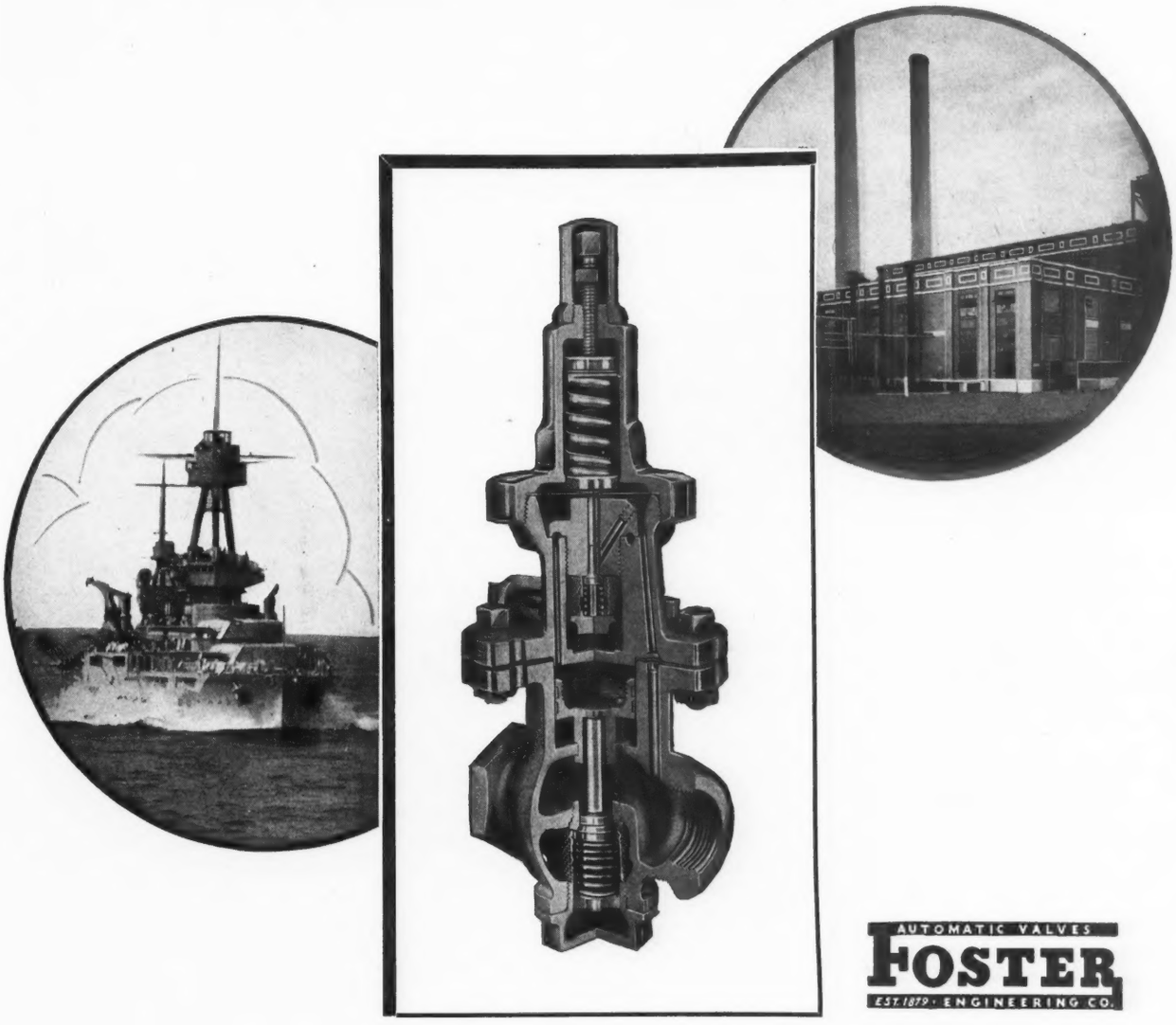
DE LA VERGNE ENGINE CO.

Sales Agent for BALDWIN-SOUTHWARK CORP., Diesel Division, Philadelphia

Pacific Coast Representatives: The Pelton Water Wheel Co., San Francisco

DE LA VERGNE DIESEL ENGINES

PRECISION *and* RUGGEDNESS



AUTOMATIC VALVES
FOSTER
EST. 1879 · ENGINEERING CO.

It has often been said that "if you can sell the utilities and the navy, your product is okay." Granting some exaggeration to such a statement, there is no doubt that the requirements of these two groups are most severe and that the equipment they buy must be right. They have too much at stake to risk inferior or unsuitable equipment.

The utilities and the navy use Foster Automatic Valves . . . thousands of them, involving many standard and special types. Their precision of action and rugged endurance meet the tough assignments given them. A steady flow of repeat orders is ample evidence of this.

Industrial power plants and the process industries can put their faith in Foster Automatic Valves. With many types for meeting all conditions of steam, liquids or gas, they will find the type and size that will best meet the conditions in their respective plants.

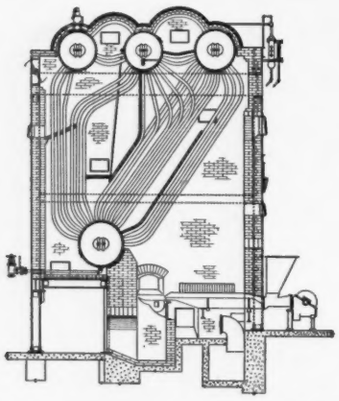
FOSTER ENGINEERING CO.

109-113 Munroe Street, Newark, N. J.

SEVENTY YEARS OF PROGRESS

1864—1934

"Three score years and ten" of continuous building of boilers without a shutdown



Type "DC" Water Tube Boiler

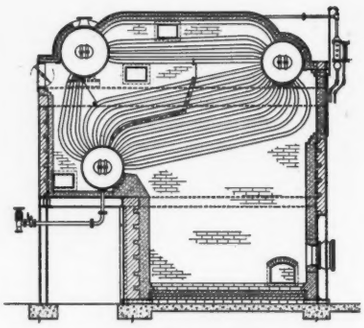
PRESSURE PIONEERS

350 pounds in.....1909
350 pounds in.....1934

No pressure cut in .....25 years

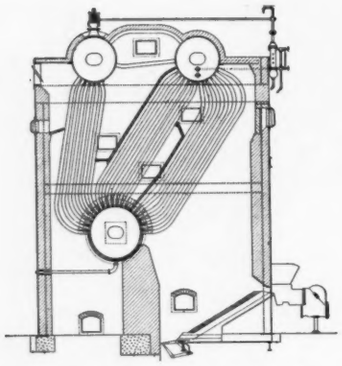
Such a report has just been received from one Pennsylvania user of Keeler boilers. Similar records have been made by hundreds of Keeler boilers.

Keeler straight tube boilers are built in pressures up to 400 lbs.; curved tube in pressures up to 600 lbs.



Type "J" Boiler

UNDIVIDED RESPONSIBILITY

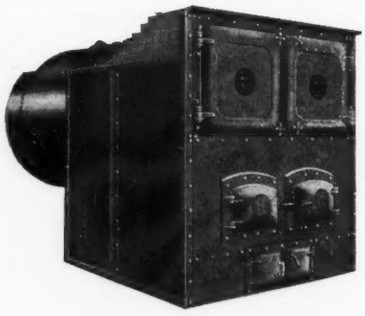


Type "P" Water Tube Boiler

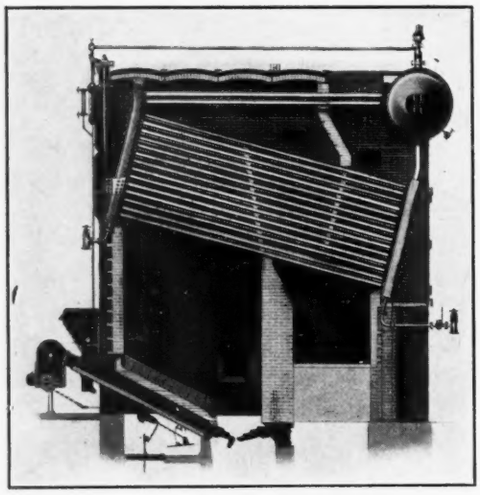
While specializing in the building of boilers, we contract to make complete installation of boilers, brickwork, stokers, oil-burners, pulverizers, soot blowers, stacks and breechings.

You are not confined to one particular make, and yet undivided responsibility can be obtained by placing your contract with us for a complete installation.

We maintain a staff of experienced Erecting Engineers.

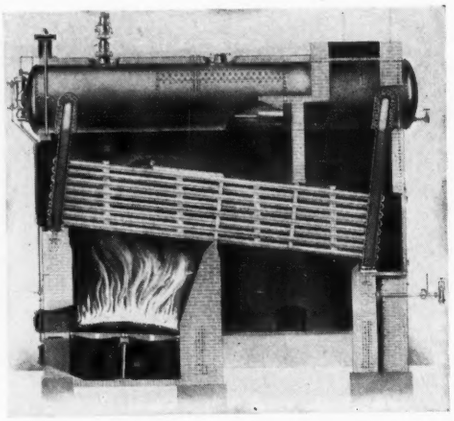


Double Duty Boiler



Cross Drum Water Tube Boiler

Bulletin of any type KEELER BOILER Will be sent on request.



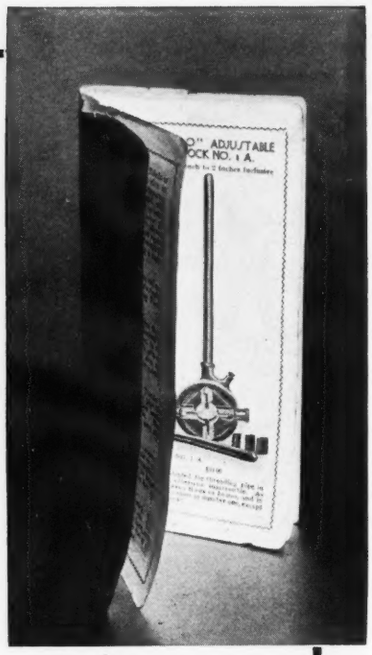
Longitudinal Drum Water Tube Boiler

E. KEELER CO.

1864 **WILLIAMSPORT, PA.** **1934**

REDUCE STEAM COSTS by CHART RECORDS
More than 50 New Features in this New Brown Potentiometer Pyrometer
— founded on 70 Years of experience in helping industry measure temperatures accurately!
For seventy years The Brown Instrument Company has been building temperature measuring instruments for industry. All of these years of experience are back of the new Brown Potentiometer Pyrometer.
There are more than fifty new features in the new Brown Potentiometer Pyrometer. Features such as the extra long slide wire for greater accuracy—slide wire and balancing rheostat immersed in oil for protection against wear and corrosion—non-slip driving clutch—humidity compensator for chart—extra housing for galvanometer—interchangeable mounting of cases—and many others.
Details of these remarkable advantages are described in Catalog 1101. Write for copy.
THE BROWN INSTRUMENT COMPANY
4485 Wayne Avenue Philadelphia, Pa.
BROWN POTENTIOMETER PYROMETER
Brings Laboratory Accuracy to Industry
This Record Shows Steam Production
This Extra Record Shows When the Steam is Delivered and How Much!
Brown Electric Flow Meter
on the Inductance Bridge Principle
New and Entirely Different
Years of Research Perfected New Instrument
The New BROWN THERMOMETER
6% TO 12% AND YOUR FUEL BILL!
Brown Electric CO_2 Meter
to measure is to economize
1
2
3
4
Recorders furnish facts—
STACK TEMPERATURES: Losses due to excessive temperatures of flue gases are checked by Brown Potentiometer Pyrometers. Get Catalog 1101.
STEAM GENERATION: It is easy to allocate steam costs accurately with a record of steam flow for any period of the day or night. Use Brown Flow Meters. See Catalog 2002.
FEED WATER: For maximum operating efficiency let the new Brown Thermometer check feed water temperatures accurately. Ask for Catalog 6702.
COMBUSTION: Efficent combustion is maintained only by recording % CO_2—regardless of load. Brown CO_2 Meters enable the operator to hold the correct air ratio. Write for Catalog 3004.
Let Brown Engineers write you regarding these problems or send for the above catalogs. No obligation—address
NRA MEMBER U.S. WE DO OUR PART
THE BROWN INSTRUMENT COMPANY
4490 Wayne Avenue, Philadelphia, Pa.
Branches in 22 Principal Cities
Brown Instruments
" to measure is to economize "

IN 1902
THE 1ST "TOLEDO" CATALOG



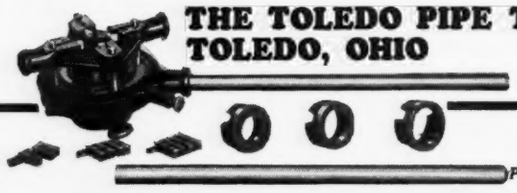
The first "TOLEDO" catalogue issued in 1902, a small 8-page pamphlet—showed just four "TOLEDO" tools, the pioneers among so called easy operating pipe threaders. Today in 1934, the fourteenth "TOLEDO" catalogue contains over one hundred pages showing sixty different "TOLEDO" tools and pipe machines, the most complete line of pipe threading and cutting equipment on the market today. Equipment to meet every possible need of the trade.

Both catalogues illustrate and describe the "TOLEDO" No. 1 and No. 1A, 1 in. to 2 in. threading devices, and during all these thirty-two years, these two tools with slight changes, have proven the most popular of all threading tools.

The "TOLEDO" die receding principle which eliminates friction in cutting and produces smooth perfectly tapered threads with minimum working parts has never been improved upon. As in 1902, "TOLEDO" is the leading line of pipe tools. The very fact that "TOLEDOS" have been repeatedly imitated is the sincerest form of flattery.

If you would secure the ultimate in pipe threading and cutting satisfaction, insist upon genuine "TOLEDO" Trade Mark tools. A copy of this new "TOLEDO" catalogue will be gladly sent you on request.

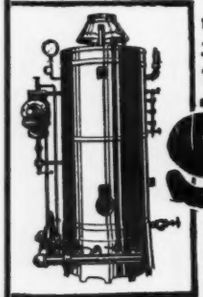
THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO
NEW YORK OFFICE, 72 LAFAYETTE ST.



"TOLEDO" NO. 1A RATCHET THREADER

FOR 32 YEARS MOST POPULAR 1" TO 2" TOOL

Summer-Steam



It's positively wasteful to run "Heating Boilers" during the hot summer months at a fraction of their rated capacity merely to supply Process or Experimental Steam Requirements.

Put a KANE Gas Fired Steam Boiler in your Plant for these "special requirements," and you'll SAVE MONEY on Fuel, Ash Handling Charges and Labor—and in addition, you'll be assured of plenty of clean steam at unvarying pressures. Of course, the KANE is AUTOMATIC—and what's more, it's SAFE.

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Executive Offices and Factory
1903-1915 EAST HAGERT ST., PHILADELPHIA
Branch Offices or Distributors in Principal Cities
Also makers of the well-known OFELDT Water Tube Gas Steam Boiler and M-K-O Automatic Boiler Feed Pump.

More air *per horsepower!*

For every form of industrial ventilation, Bendix P-V-P Ventilating Fans provide the exact volume of air flow desired. Due to unique Bendix propeller blade design and Bendix Venturi Ring, *more air per horsepower,* and smooth flow of air without eddies, are assured.

A BENDIX PRODUCT

All types—wall, ceiling, floor and portable—all sizes, 16″ two-blade to 36″ four-blade. One quality, employing finest forged aluminum alloy blades, rolled steel frames and motor supports. Bendix engineering counsel always available for your special ventilation problems. Write

BENDIX P-V-P FANS

BENDIX PRODUCTS CORPORATION
(Industrial Fan Division)
401 Bendix Drive, South Bend, Ind.

BENDIX FANS

For More Than Thirty Years

VULCAN

SOOT BLOWERS

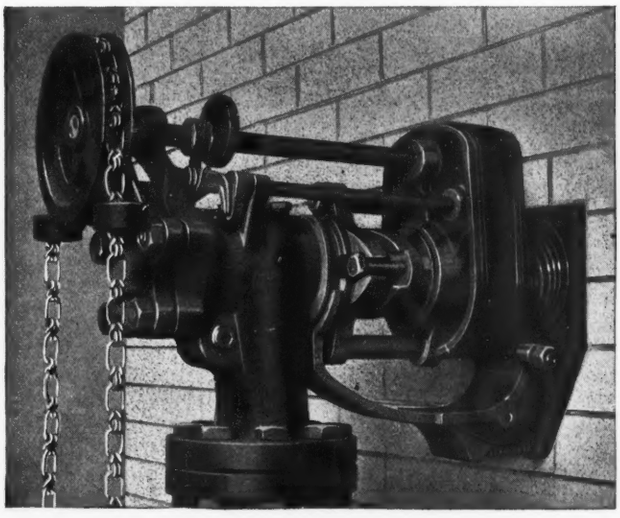
have been cutting Boiler Plant Costs

THE wide use of Vulcan Soot Blowers by leading industrial and public utility companies throughout the entire country constitutes the best possible evidence of their superior design and construction. Thirty years of continuous research and development have enabled us to meet every recent advance in boiler plant practice with soot blowing equipment of correspondingly advanced design and efficiency.

● Progressive engineering policies, modern manufacturing methods and the liberal use of heat resisting alloys, make present-day Vulcan Soot Blowers more efficient, more durable and more economical to operate than ever before. And no matter what new problems in soot removal the future may bring to operators of boiler plants, Vulcan Engineers and Vulcan manufacturing resources can be relied upon to maintain Vulcan superiority in this highly important field.

● Write us regarding any present or prospective problem in keeping boiler tubes free from soot. Our engineers will be glad to make constructive suggestions without charge or obligation of any kind.

VULCAN SOOT BLOWER CORPORATION
Du Bois, Pennsylvania



Vulcan Model L (Ratchet Operated) Valve Operating Head

One chain automatically controls synchronized operation of steam (or air) supply and element rotating mechanism. Step-by-step rotation assures better cleaning with more economical use of steam. Superior design and materials assure long life and low maintenance cost.

Partial List of Vulcan Soot Blower Users

Abitibi Power & Paper Co.
Adirondack Power & Light Corp.
American Bridge Co.
American Can Company
American Metal Co.
American Seating Company
American Sheet & Tin Plate Co.
American Steel & Wire Co.
American Thread Co.
Armour & Company
Atlantic Refining Company
Atlas Portland Cement Co.
Atmospheric Nitrogen Corp.
Atwater Kent Mfg. Co.
Walter Baker Co., Inc.
Baltimore Consolidated Gas Electric Light & Power Co.
B. & O. Railroad Co.
D. M. Bare Paper Co.
The Barrett Co.
City of Bartow, Fla.
Bell Telephone Co.
Beloit College
Bemis Bros. Bag Co.
Bergstrom Paper Co.
Bethlehem Steel Co.
Bourne Fuller Co.
Brockway Motor Truck Co.
Brooklyn Edison Co., Inc.
Brown & Sharpe Mfg. Co.
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Bunte Brothers
A. M. Byers Pipe Co.
By-Products Coke Corp.
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Carnegie Steel Co.
Celanese Corp.
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AUTOMATIC OIL PUMP
With new FRICTION CLUTCH MOVEMENT,
Which is noiseless in operation
SIGHT FEED
Absolutely Free
from steam and water
Is the only complete and perfect article on the market for lubrication of engines and pumps.
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FORCE FEED LUBRICATORS

Have kept engines well lubricated for decades

For decades engineers who want to be dead sure of lubrication—and what engineer doesn't?—have used Manzel lubricators.

At the top of the page, we reproduce our advertisement of 35 years ago. Then, as now, we offered a high grade lubricator—of the very best quality available.

Today, the Manzel Force Feed Lubricator, with many improvements added as a result of our 35 years' experience, guarantees thorough, regular lubrication with highest economy. Used on all kinds of machinery, it is especially useful in the power plant for lubricating the cylinders and bearings of engines, pumps and compressors.

The oil supply is automatically controlled so that each cylinder or bearing receives exactly the right amount of oil for correct lubrication at all speeds.

Write for Catalog.

MANZEL BROTHERS COMPANY
326 BABCOCK STREET BUFFALO, N. Y.

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DEEP WELL TURBINE PUMPS

JOHN BEAN MFG. CO.
PEERLESS PUMP
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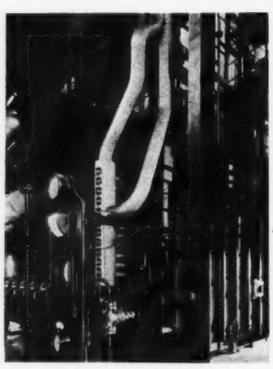
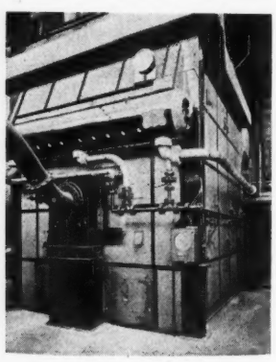
1900 E 67th STREET, LOS ANGELES, CALIF.

WRITE FOR CATALOG containing latest engineering data

Do you want your maintenance costs to be among the LOWEST





Investigate the MODERN DEWOLF FURNACE

It gives you High Capacity, Flexibility, Low Wall Loading, Wall Tightness, Ease of Repair, Low Maintenance. Meets present day demands for high ratings, high temperatures and fluctuating loads. Let us show you the ease of application of our design to specific cases and performance data on representative installations. Send for bulletins.

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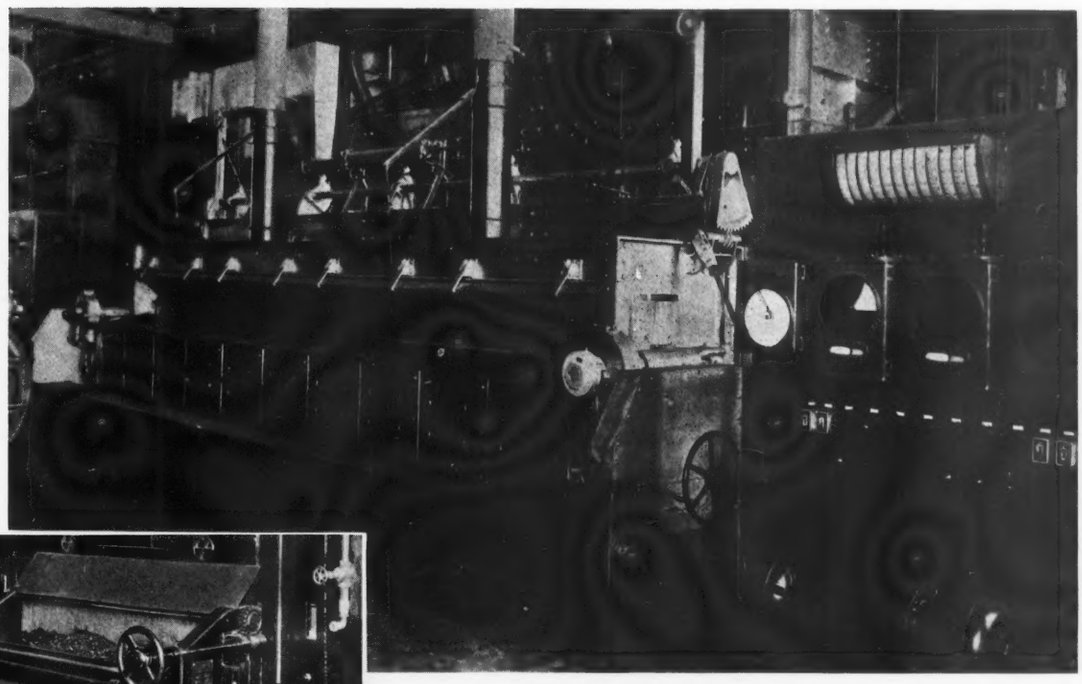
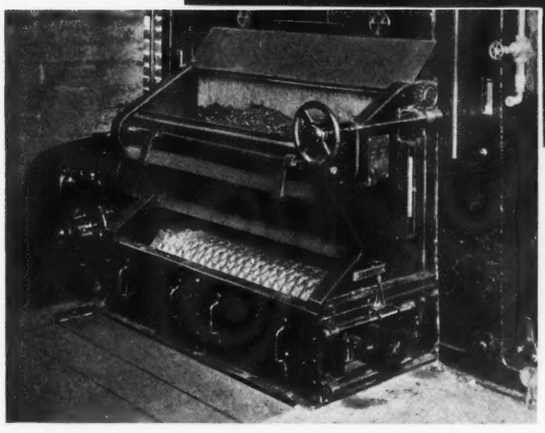
ILLINOIS CHAIN GRATE STOKERS

Contributing to the Progressive Advancement in

STOKER PERFORMANCE



Forced Draft Stoker Under 1500 H.P. Boiler



Forced Draft Stoker Under 100 H.P. Boiler

All stokers either forced or natural draft have zoned air control.

Especially designed for preheated air.

Grates are self-cleaning, with automatic removal of siftings.

This Company has built stokers totalling more than 175,000 sq.ft. of active grate surface.

IN twenty-six years the Illinois Stoker Company has witnessed the development of the super-power station and has taken a prominent part in the design and furnishing of equipment demanded for these stations, where midwestern coals are used.

Today this experience is available to the small boiler user as well as the large. Considering the stoker only the small installation pictured above is as efficient as the large one, which preceded it in design.

Our location in the heart of the Midwestern coal fields has afforded a unique opportunity for the study of the proper co-ordination of furnace and stoker for handling these particular coals, so that today the Illinois Stoker Company believes it is in a position to offer to all boiler users equipment and experience that is unequaled in the burning of Midwestern coals.

Illinois stokers are continuously being improved to meet changing operating conditions, the engineering department is still fully intact and will gladly consult with you on your combustion requirements.

ILLINOIS STOKER COMPANY
Alton, Illinois

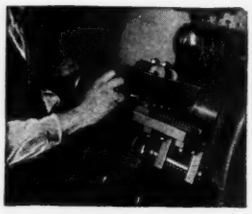
ILLINOIS CHAIN GRATE STOKERS

IDEAL

GUARANTEES INCREASED EFFICIENCY AND LOWER PLANT MAINTENANCE COSTS

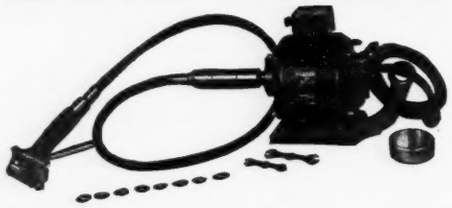
First choice with over 17,000 engineers and maintenance men, **IDEAL Stones** eliminate costly and prolonged shut-downs — maintain commutators and slip rings at peak efficiency *all the time.* 175 sizes —5 grades.

Trues to 1/1000 of an inch

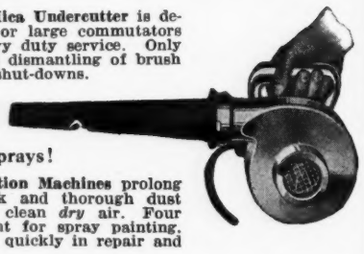


IDEAL Precision Grinders true commutators and slip rings in their own bearings at normal operating speed — without disassembly. Greater speed, greater accuracy, less cost.

Undercuts Mica Without Removing a Single Brush



The **IDEAL Universal Mica Undercutter** is designed for either small or large commutators and for continuous heavy duty service. Only 2¾" space required—no dismantling of brush rigging—saves lengthy shut-downs.



Blows! Suctions! Sprays!

IDEAL 3 in 1 Combination Machines prolong equipment life by quick and thorough dust and dirt removal with clean *dry* air. Four models. Equally efficient for spray painting, they pay for themselves quickly in repair and labor savings.

FREE TRIAL

IDEAL Motor Maintenance Equipment KEEPS electrical machinery in service—KEEPS it efficient—and lowers Power Department costs. We invite you to prove this statement by requesting any item on 10-DAYS FREE TRIAL. No obligation. Send the coupon today!

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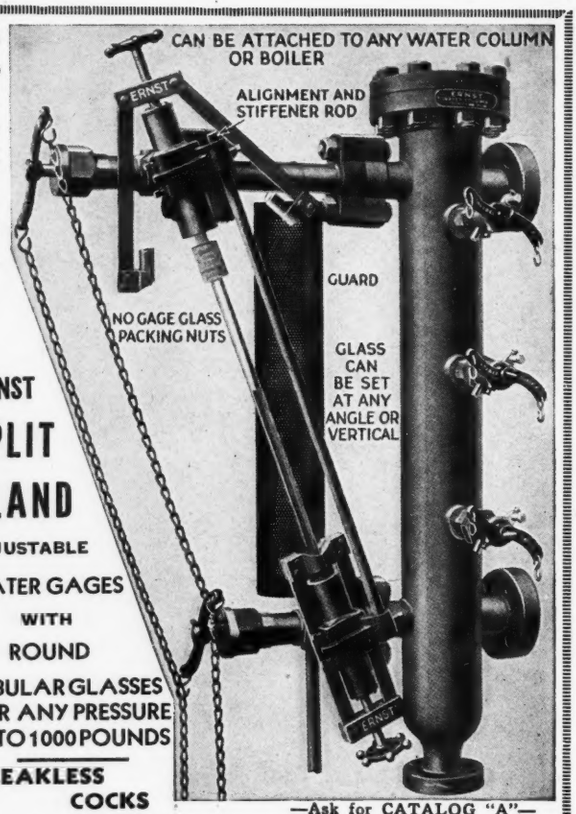
SPECIFY


CAN BE ATTACHED TO ANY WATER COLUMN OR BOILER
ALIGNMENT AND STIFFENER ROD
GUARD
NO GAGE GLASS PACKING NUTS
GLASS CAN BE SET AT ANY ANGLE OR VERTICAL

ERNST SPLIT GLAND ADJUSTABLE WATER GAGES WITH ROUND TUBULAR GLASSES FOR ANY PRESSURE UP TO 1000 POUNDS

LEAKLESS COCKS

—Ask for CATALOG "A"—
See our other ad on page 210

ERNST WATER COLUMN & GAGE CO., - NEWARK, N. J.
New York: W. K. Sowdon Co., 342 Madison Ave.—Chicago: J. J. Russo, Record Bldg.
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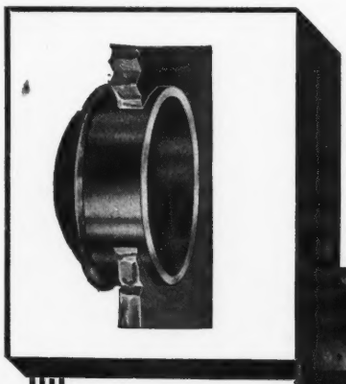
NUT BITUMINOUS VICTOR COAL **LUMP**

Produced in all sizes by us in the heart of Central Pennsylvania's field, low and medium volatile, and of uniform and dependable quality.

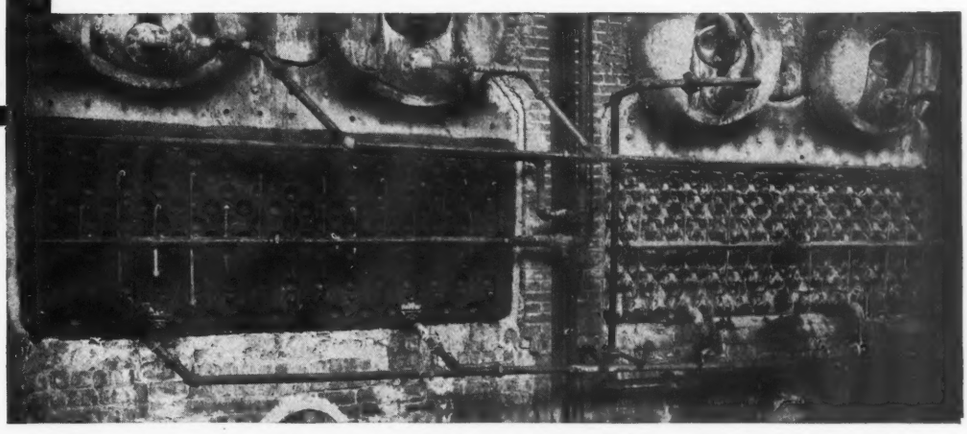
Our Fuel Service Engineers are at your call. They are qualified to aid you in getting the utmost in satisfaction, efficiency and economy from your equipment and the specific conditions under which it operates.

Standard Quality Anthracite



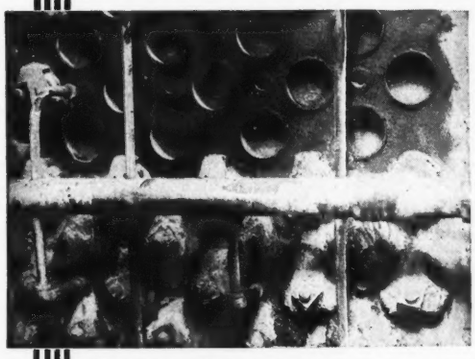
KEY Safety Hand Hole Caps

The above cross-sectional view shows the simplicity of the Key Safety Hand Hole Cap. The tapered construction makes it self-tightening under pressure. No gaskets to worry about.

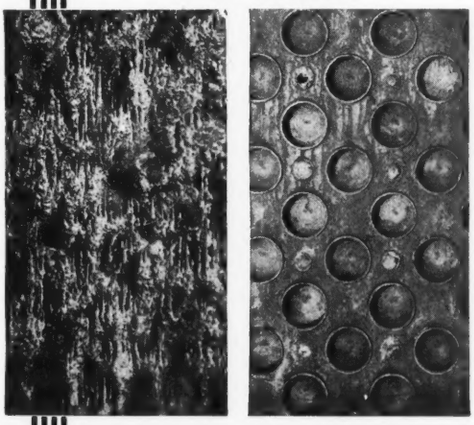


Note the clean, efficient installation of Key Caps in the boiler at left as compared to the boiler at right equipped with gasket-type closure plates. No hand hole leaks and lost pressure when Key Caps are used. No time is wasted cleaning scale (un-retouched photograph).

Reduce Boiler Maintenance Cost and Assure Maximum Safety



This trial installation of just a dozen Key Caps resulted in the complete installation in three boilers in a mid-Western beverage plant (un-retouched photograph).



Compare these sectional views of boiler headers. Both have been in operation about the same length of time. Note the clean, scale-free surface when Key Caps are used. Think of the time necessary to strip the header and clean the tubes in boiler at the left (un-retouched photographs).

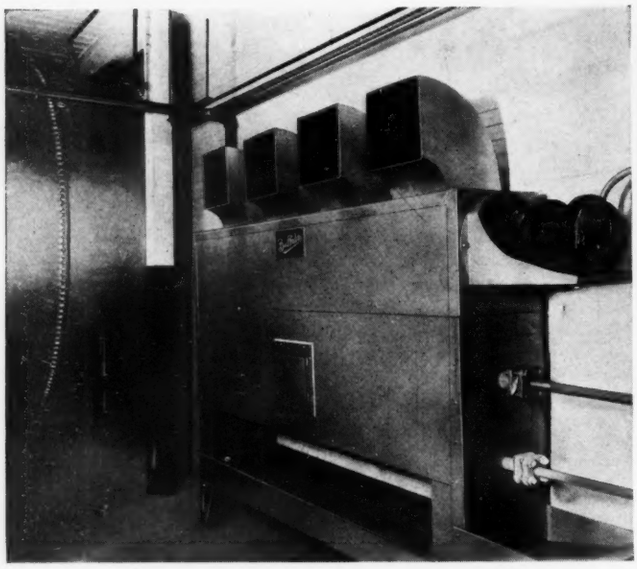
By using Key Safety Hand Hole Caps, you can hold your boiler maintenance to the very minimum . . . they are simple to install . . . no gaskets, nuts, crabs or bolts . . . they are of one-piece construction, leak-proof and self-tightening.

Key Caps are made for use in either new or old water-tube boilers with round hand hole openings. Our skilled mechanics will install them, properly machining the hand holes to the correct taper and size to insure customer's entire satisfaction. With Key Caps in your boilers, it is a simple matter to strip for tube cleaning. Just a rap with a maul and out they come. Re-inserting is just as easy. Think of the time saved as compared with the old crab and gasket type plates. And in addition, they assure absolute safety . . . tested to sustain pressure loads of 3000 lbs. per square inch. Over 7,000,000 have been sold . . . this attests to their popularity.

Write for complete details and prices . . . our engineers will be glad to make recommendation and show you how you can save money and get highest boiler efficiency.

KEY BOILER EQUIPMENT COMPANY
EAST ST. LOUIS, ILLINOIS

Unit Coolers provide operating Economy—



Floor Type Buffalo Unit Cooler Installed in Brewery

Buffalo Unit Coolers—both floor and suspended types—provide economical and efficient cooling—because they are built for very close regulation by automatic controls. Because our line of units is so complete (three types for all refrigerants, more than a dozen models) we can make recommendations which will fit your requirements most accurately. Before you purchase cooling coils or unit coolers let Buffalo engineers make recommendations.

BUFFALO FORGE COMPANY
488 Broadway, Buffalo, N. Y.
In Canada: Canadian Blower & Forge Co. Ltd., Kitchener, Ont.

Other "Buffalo" products—
Unit Heaters
Ventilating Fans
Air Conditioning Apparatus
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DRAFT FANS

Reduce Refractory maintenance with

J-M HELLITE

Ready mixed for BRICK SETTING . . . WASH-COATING . . . and HOT-PATCHING

Recommended for Temperatures up to 3000° F.

Write for BROCHURE-RC-6A
Johns-Manville
22 East 40th Street, New York City

FULL AREA
gives added safety

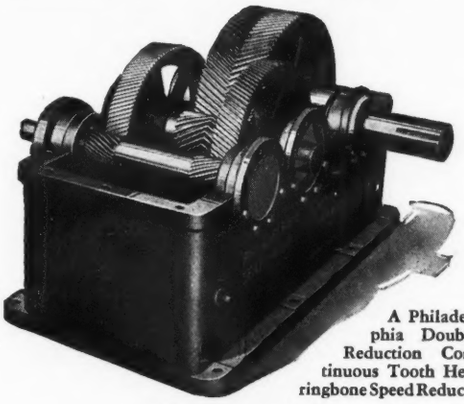
Davis Exhaust Relief Valves — condenser safety valves — hold tight under vacuum and relieve to atmosphere at a fraction of a pound pressure giving full and immediate atmospheric relief. Pressure accumulation that might damage costly equipment is prevented. Davis design provides full pipe area not only through the port but through all body passages as well. This feature has influenced many experienced engineers to specify Davis Exhaust Relief Valves for this important service. They get full condenser protection. Hand and hydraulic lift types. Horizontal, vertical and angle patterns.

DAVIS REGULATOR COMPANY
2540 S. Washtenaw Avenue Chicago, Illinois

DAVIS VALVE SPECIALTIES

Reduced Speeds —and Reduced Costs

A Philadelphia MotoReduceR (Horizontal Type)



A Philadelphia Double Reduction Continuous Tooth Herringbone Speed Reducer

Type AT Worm Gear Speed Reducer

—when you use

Philadelphia
SPEED REDUCING UNITS
(ONE NAME-ALL TYPES)

In these days when increased costs must be offset by lower operating expense, consideration should be given to the power transmission problem.

The most economical and efficient method of transmitting power from a prime mover to a driven machine is through Philadelphia Speed Reducing Units. These units constantly deliver the maximum of "input" power. They operate with a minimum of upkeep cost and are extremely long lived.

For every industrial speed reduction problem there is a Philadelphia Unit to fit it. They are made in all Types and Sizes. Let our engineering department recommend the proper unit for your need.

PHILADELPHIA GEAR WORKS

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Industrial Gears and Speed Reducers
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STEAM HOG?

FISHER Type ST Inverted Bucket Steam Traps for pressures up to 150 pounds.

FISHER Type No. 33 Heavy Duty Open Bucket Steam Trap for all pressures up to 600 pounds.

Kill the Steam Hog with

FISHER

Steam Traps

Your biggest profits in 1934 are going to be made by decreased production cost. When you are searching for corners to cut, don't overlook your steam costs. Many plants are wasting thousands of pounds of steam by old, worn, inefficient Steam Traps or worse by not using Steam Traps at all.

The efficiency of any steam kettle, cooker, dryer, evaporator, mangle, or similiar equipment can be increased 10 or 15% by the correct use of Steam Traps.

For pressures from 1 to 150 pounds the Inverted Bucket FISHER Type ST will give excellent results and pass large volumes of condensate at cost which will be returned by steam savings in a few months time. Will not air bind.

For heavy duty service and higher pressure, the FISHER Type No. 33 Open Bucket Trap is unexcelled. Passes exceptionally large volumes of condensate and will not air-bind.

Kill that Steam Hog with the FISHER Steam Traps—for over fifty years recognized as the standard.

If you have not received your copy of the new FISHER catalog covering not only the Traps but the complete line of automatic controls, write for your copy today.

NRA MEMBER U.S. WE DO OUR PART

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Your guarantee of service is the name D'ESTE A nationally known trade-mark for over 64 years.

Pressure Reducing Valves
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6 Spice Street, Charlestown District
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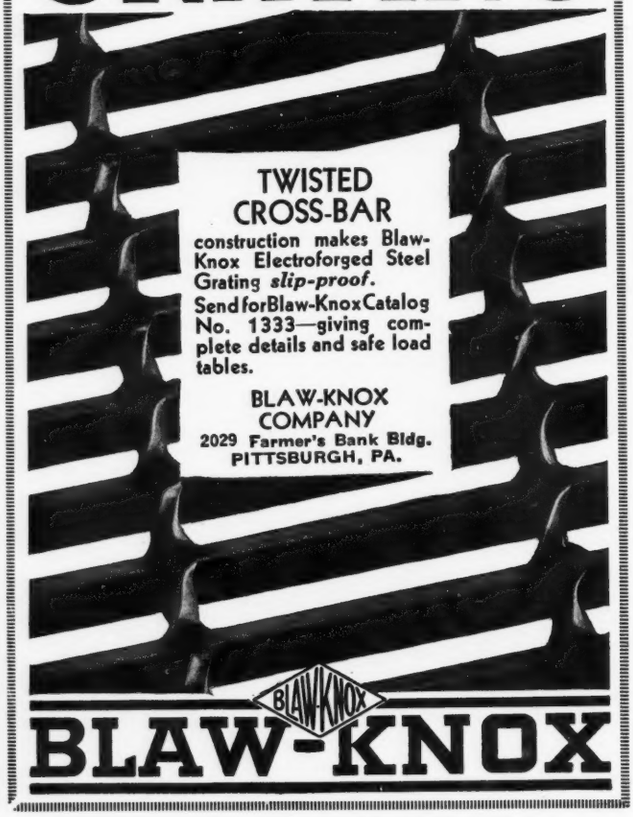
GRATING



TWISTED CROSS-BAR construction makes Blaw-Knox Electroforged Steel Grating *slip-proof*. Send for Blaw-Knox Catalog No. 1333—giving complete details and safe load tables.

BLAW-KNOX COMPANY
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FOR OVER 26 YEARS

Steam users have been SAVING MONEY with the

Morehead Back-to-Boiler SYSTEM

The Morehead
Non-Return Steam Trap
All working parts on the outside. No Valves, Floats or Buckets on the inside. No Plates or Covers to Remove to get at the working parts.
Absolutely Reliable.
d Manufacturing Co.
River Ave., Detroit, Mich.

The first Morehead Ad in POWER 1908

● **Steam plant owners in every field of industry have found the Morehead Back-to-Boiler System indispensable to efficient, economical operation. Basically correct in design, the system has proved so flexible as to meet the changing needs of plant design and operation with but little modification of original features.**

Today, and in the years immediately ahead, the thoroughly demonstrated efficiency of the Morehead System and its ability quickly to pay for itself out of savings place it in the forefront of profitable modernization projects.

If you are a user of steam for power, processing, heating, or all three, read the reports of Morehead Back-to-Boiler System savings given below, and send the coupon for further details. It will pay you.

THESE RECENT USERS' REPORTS ARE TYPICAL

Saves 25% of fuel

"Having had previous experience with a Morehead system in a factory where the saving in fuel averaged 25% and the temperature of the dryers was increased from 240 to 285 degrees with a consequent increase in production, we did not hesitate to install a Morehead system in our plant. This system has given us entire satisfaction . . . we highly recommend the Morehead Back-to-Boiler System."

◆ ◆ ◆

Production increased 15%

"We estimate that production on the finishing machines has been increased from 10% to 15%. Our finishing machines were always a source of trouble. We eliminated the individual cut-off traps, and repiped the drips as per your instructions with the result that we no longer have leaky traps to contend with, and the MACHINES ARE ALWAYS HOT."

◆ ◆ ◆

Saves 225 tons of coal annually

"We saved 225 tons of coal a year on a boiler developing about 90 horsepower, so that the Morehead Back-to-Boiler System paid for itself in one Winter's operation."

◆ ◆ ◆

Water bills cut

"The Morehead System enabled us to make such a large saving on the water bill that the city water works wanted to install a new meter, as they could not understand why we were suddenly using so little water. In addition, we have been able to ELIMINATE BOTH our VACUUM PUMP on the heating system, and the FEED PUMP on the boilers, saving the upkeep on this equipment, including oiling, repairs and waste of steam. The cost of operating the Morehead Back-to-Boiler System is negligible, and it considerably reduces the cost of general plant maintenance."

◆ ◆ ◆

Saves $250 on fuel in 6 months

"It was difficult to understand, before making our Morehead installation, where to expect all the saving to come from. However, six months after one of your systems had been in service, sure enough, it effected a fuel saving of $250, to say nothing of speeding up production."

◆ ◆ ◆

Results beyond expectation

". . . results are beyond expectations. Our trap troubles are over and the saving in fuel has more than paid for the cost of the Morehead system."

KEEP POSTED: *Mail this coupon*

Morehead Manufacturing Company
Detroit, Mich.

MOREHEAD MANUFACTURING CO.
Department P Detroit, Michigan

I'd like to know the experiences of Morehead users and to find out what Morehead methods will save me.

Name .....
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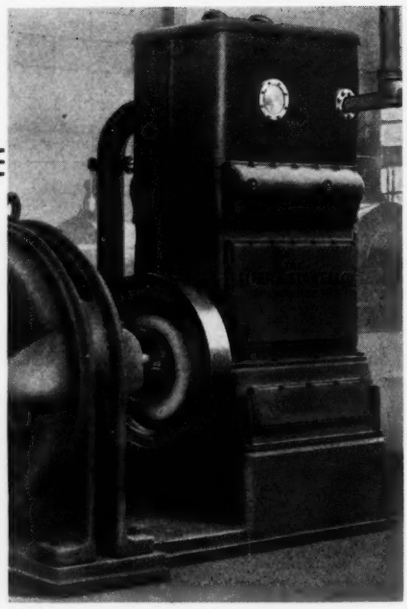
Twin Cylinder Vertical Engine direct connected to 150 K.V.A., 440 Volt, 600 R.P.M. alternator.



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50 YEARS

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More Efficient and Economical Operation

Past performance is proving valuable today because plants in making equipment investments must consider cost reducing features.

Filer & Stowell engines of all types have fully demonstrated their dependability under all conditions for over half a century.

Now as in the past there is a Filer & Stowell engine that will cut your immediate costs and those of the future.

Tell us your plans and we will send descriptive literature together with complete data and give you our full cooperation. Filer & Stowell engineers have had wide experience in all types of engine installations.

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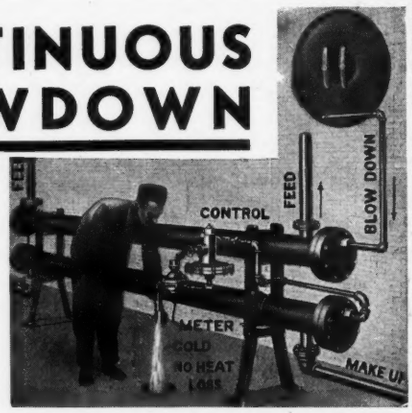

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Continuous Blowdown prevents scale, foaming, priming, corrosion, and dirty steam without heat loss.

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WATERTOWN, WISCONSIN

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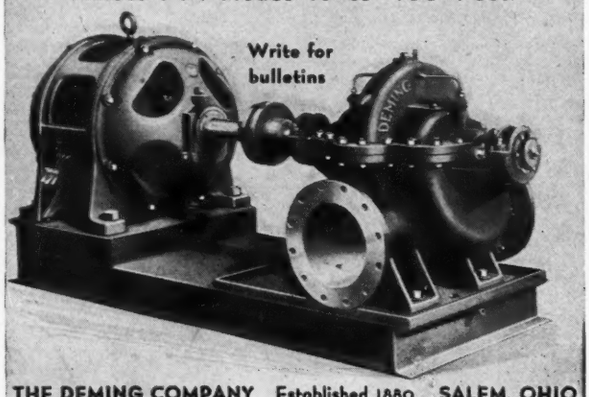
DOUBLE SUCTION

CENTRIFUGAL PUMPS

Ball Bearing Equipped . . . High Efficiencies . . . Sizes 2 to 12 Inches . . . Capacities 50 to 7500 Gallons per minute . . . Heads 10 to 400 Feet.



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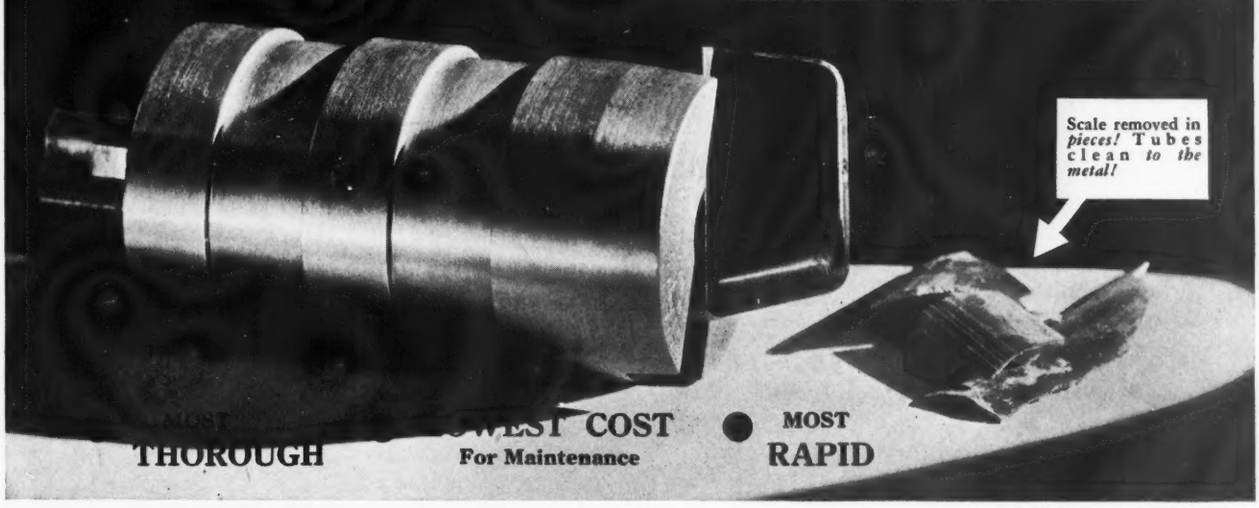
Dean Tube Cleaner

BACKED BY 37 YEARS OF TUBE CLEANING EXPERIENCE

There's a Dean for every tube cleaning job. Illustrated is the Number 20 Model—the last word in a durable efficient cleaner for water tube boilers. It cleans *both* sides of the tubes to the bare metal—*as do all Deans.* Consult us on your next tube cleaning job of any kind and profit by the experience of the country's oldest tube cleaner manufacturer.

THE WILLIAM B. PIERCE COMPANY
CAXTON BLDG., BUFFALO, N. Y.



MOST THOROUGH ● LOWEST COST For Maintenance ● MOST RAPID

It may be 15 Years . . .

before you pack your next piston rod, shaft, or valve stem, if you apply **Conneaut Plastic Metallic Packing** *now.* It lasts indefinitely—5, 10, 15 years and more. Ideal for saturated or superheat steam, air, gas, or ammonia.

Write for bulletin and sample package.

The Conneaut Packing Company

Conneaut (Since 1916) Ohio

ALLAN RED METAL

. . . *a quality product for 43 years*

Since 1891, Allan Red Metal has been reducing friction and cylinder wear on the engines, compressors and pumps of the foremost builders. Millions of pounds of this quality metal have been supplied as segment castings for facing pistons.

In addition, Allan No. 2 Red Metal—a copper-lead alloy—has contributed economy, dependability and long life to the bearings on all classes of power plant equipment.

Allan Red Metal will continue a quality product through the years to come.

A. ALLAN & SON

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297

Different Companies *This Year*

DURING the past 12 months 297 different companies, operating in every major American industry, have employed the Fuel Engineering Company organization with regard to special and routine operating problems having to do with coal selection, boiler room management and plant modernization.

For 27 years Fuel Engineering Company has specialized in this field. Here is knowledge and experience of a highly technical character—so organized and operated that its results are available to industrial executives as an aid to better management control over a branch of expense that is constantly becoming more important.

Interested executives are invited to write about their problems.

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Specializing in Heat Exchange Maintenance

THE AIR AND EROSION ELIMINATOR stops erosion of tube ends. Installation statistics show tube life doubled or tripled by this device.

THE HYDRO-DYNAMIC SHOCK TEST applied to tubes in or out of place, destroys defective tubes, prevents failures in service. Avoids discarding of good tubes prematurely.

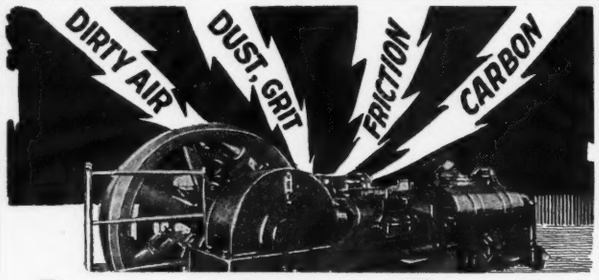
"FLOW-RITES" are condenser-tube inserts which eliminate erosion at tube ends and reduce frictional resistance in water flow.

These three developments are the result of thorough practical experience in maintenance and service in hundreds of hundreds condensers and heat exchangers for many outstanding companies under widely varying condition. The same broad experience enables us to retube heat exchange equipment with unusual speed, as well as to locate and overcome the cause of maintenance and operating troubles with certainty and dispatch.

Our service available 24 hours a day, 7 days a week.

May we have an opportunity to discuss your heat-exchange problems?

Condenser Service & Engineering Company
310 Twelfth St. Hoboken, N. J.



Beware of these Enemies

The protectomotor Air Filter is *guaranteed* to eliminate 99-9/10% of the dust and dirt from air delivered to machines. Consequently it
—Reduces 75 to 85% of the wear on cylinders, pistons, bearings and valves.
—Cuts down carbon deposits 60 to 70%.
—Enables machines to operate from 3 to 5 times longer without overhauling and makes them more efficient.
—Eliminates loss of costly compressed air, wasted when valves stick.
—Reduces oil consumption materially, and silences noise.

Write for catalog and information about our 30 day FREE trial offer.

STAYNEW FILTER CORP.
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PROTECTOMOTOR
REG. U.S. PAT. OFF.
99 9/10 Per Cent EFFICIENT
AIR FILTERS

Warren SCORES AGAIN

Another member of the Warren line has been accepted by Industry. This new, close-coupled pump has all of the characteristics that have made *Warren* an outstanding name wherever pumps are used . . . in design, in construction, in materials it has merited and been given approval.

To design and build pumps that provide their users with the lowest possible pumping cost per year has been the goal toward which Warren has worked. This new close-coupled unit is no exception . . . it is compact, sturdy and has balance and a smoothness of operation that insure long life and low maintenance.

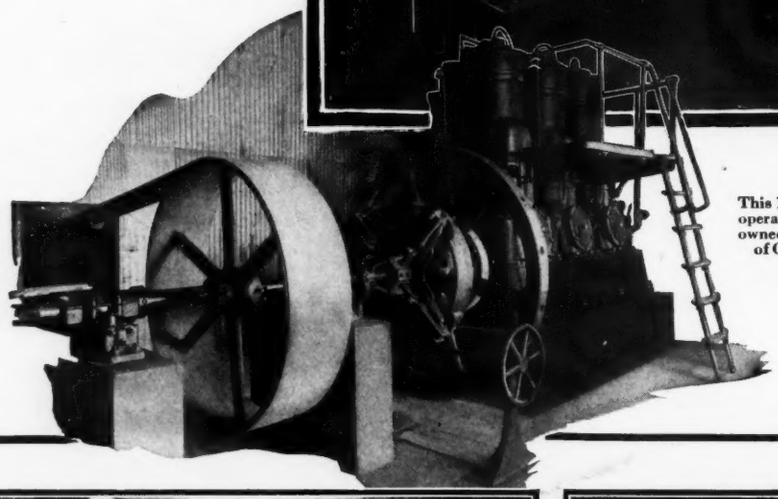
Write today for further details about this new member of the Warren line.

WARREN PUMPS

WARREN STEAM PUMP CO., INC., WARREN, MASSACHUSETTS

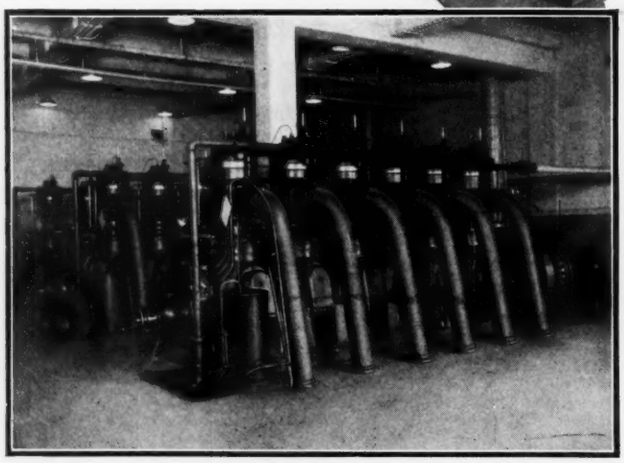
F-M Complete Service

A 240 hp. F-M Diesel operates an F-M Generator and Multi-stage centrifugal pump on this U. S. Engineers Grader and Derrick boat.

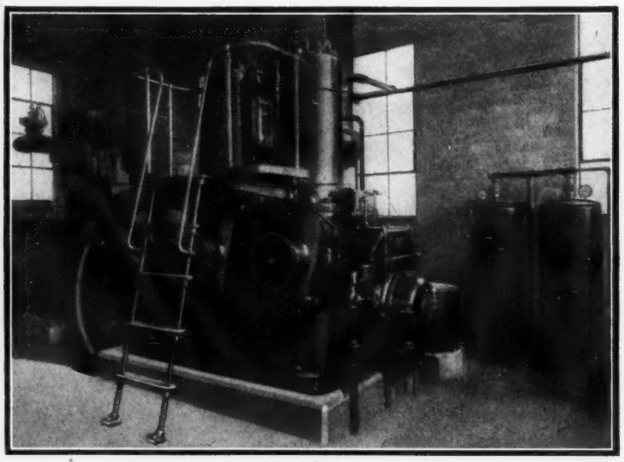


This 180 hp. F-M Diesel operates the cotton gin owned by C. W. Brown of Groesbeck, Texas

Over 2,000,000 Horsepower now in service



These three 360 hp. Fairbanks-Morse Diesel generating units supply power for the Gates Lumber Co., in the very heart of metropolitan New York.



The Westfield Marble Quarries at Westfield, Mass., use this 120 hp. F-M Diesel with a resulting power saving of about $3,000 yearly.

assures you the ultimate in Diesel efficiency and economy . . .

IN most instances Fairbanks-Morse engineers, called in by prospective buyers of Diesel engines, can suggest improvements in power layout and transmission that will result in substantial savings. Power analysis by men qualified to advise on any power problem is an important part of Fairbanks-Morse service. It protects your investment by assuring a maximum efficiency that can be obtained only when power is "fitted" to the requirements of the particular job. ¶ Fairbanks-Morse' facilities for serving the users of Diesel engines are unequaled. Completely equipped service stations and competent staffs of engineers are maintained throughout the United States and in principal cities the world over. When you buy a Fairbanks-Morse Diesel you can be sure that, regardless of the number of years your engine is in use, prompt service will always be available. ¶ Before you buy a Diesel engine, consider carefully the *plus* value of F-M service. Bear in mind that only the great resources of Fairbanks-Morse—America's largest manufacturer of Diesel engines—make possible this *complete* service that protects F-M Diesel users and assures them the ultimate in Diesel efficiency and economy.

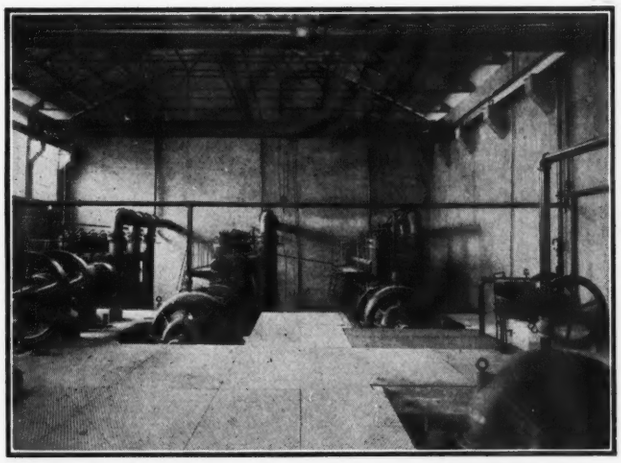
FAIRBANKS, MORSE & CO., 900 South Wabash Avenue, Chicago

32 branches at your service throughout the United States

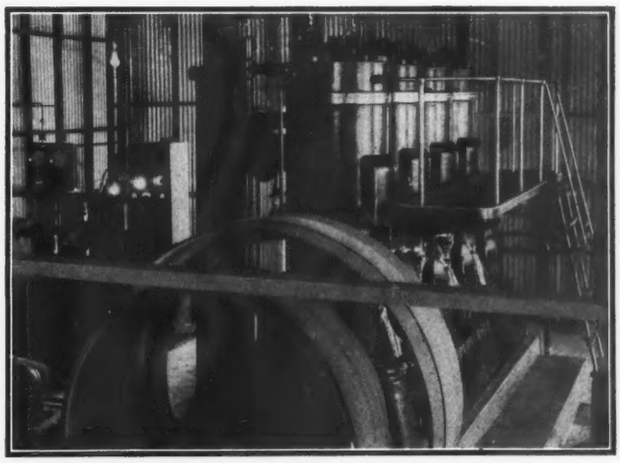
FAIRBANKS-MORSE

DIESEL ENGINES

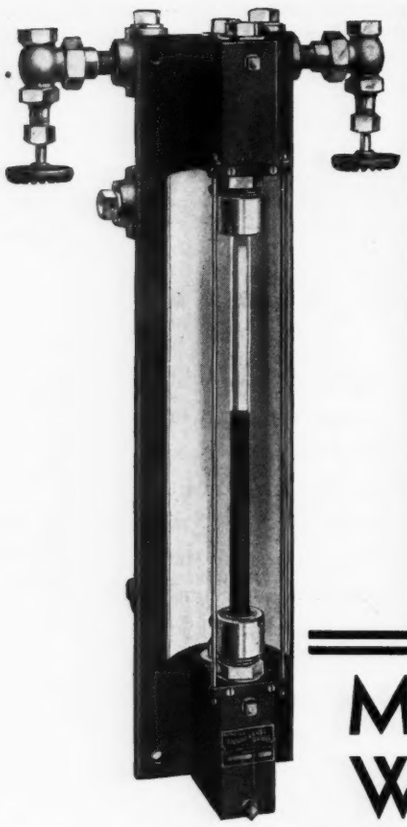
POWER PUMPING AND WEIGHING EQUIPMENT



F-M Diesels used by the Hidalgo County Water Control and Improvement District No. 1 at Edinburg, Texas. More than 50,000 hp. of F-M Diesels are in service in the Rio Grande Valley.



Starting with a 75 hp. F-M Diesel in 1925, the Holtville Ice & Cold Storage Co., Holtville, Calif., have added at intervals units of 80 hp., 240 hp. and 120 hp.



SHOWS YOUR BOILER — WATER LEVEL — AT ALL TIMES

Twenty years of successful engineering is back of this modern and widely used piece of equipment. Never a guess — never a mistake — you always know your boiler water level when you use The McNeill Remote Liquid Level Gage because it can be located ANYWHERE at any distance from the boiler. It is dependable, safe and accurate. Can be read at a glance — note the sharp, easily read, line of demarcation produced by the use of **black fluid.** Permits operating at higher boiler capacities with safety. Can be used with any pressure up to 2000 lbs. Install it to save money, increase efficiency, and improve operating conditions.

McNEILL REMOTE WATER LEVEL GAGE

The McNeill Liquid Level Gage is subject only to boiler pressure and **never** to boiler **temperature.** Even under the highest steam pressure, gage remains at room temperature. No gage glass breakage from erosion or heat change. **Steam never reaches the gage.** Instead, condensation at boiler pressure remains in the pipe connections at all times.

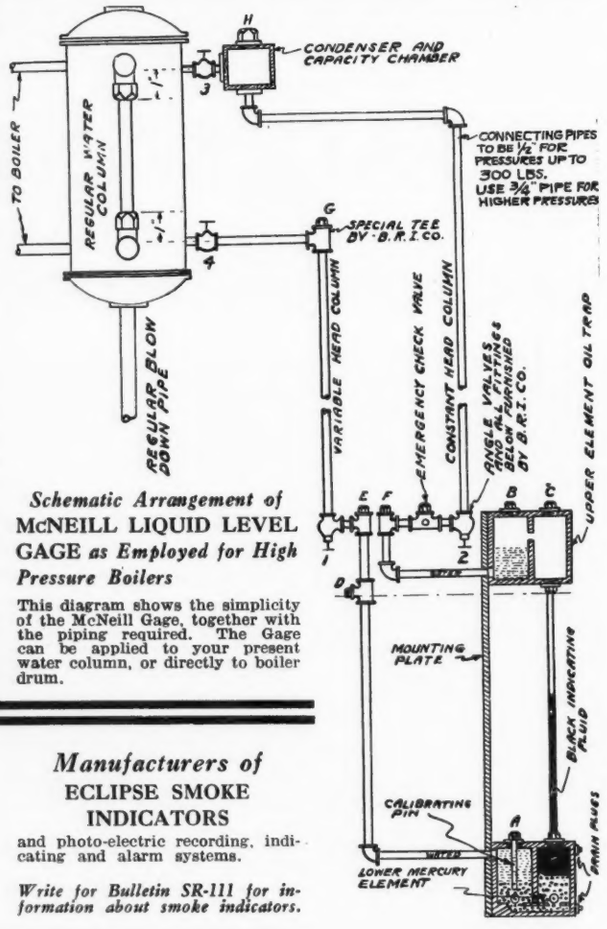
No mechanical parts to get out of order. No floats — No springs — No electricity — No air. Entirely hydrostatic.

SOME REPRESENTATIVE USERS

Jersey Central Power & Light Co., South Amboy, N. J.
1400 Lbs. Boiler Pressure.
Elgin, Joliet & Eastern Ry. Co., Joliet, Ill.
American Thread Co., Willimantic, Conn.
Staley Mfg. Co., Decatur, Ill.
Armour Soap Works, Chicago, Ill.
Sinclair Refining Co., East Chicago, Ind.
Studebaker Corporation, South Bend, Ind.

WRITE FOR

Bulletin 101-G for information about Remote Liquid Level Gage.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CONDENSER AND CAPACITY CHAMBER
TO BOILER
REGULAR WATER COLUMN
CONNECTING PIPES TO BE ½" FOR PRESSURES UP TO 300 LBS. USE ¾" PIPE FOR HIGHER PRESSURES
G
SPECIAL TEE BY B.R.I. CO.
VARIABLE HEAD COLUMN
EMERGENCY CHECK VALVE
CONSTANT HEAD COLUMN
ANGLE VALVES AND ALL FITTINGS BELOW FURNISHED BY B.R.I. CO.
REGULAR BLOW DOWN PIPE
UPPER ELEMENT OIL TRAP
MOUNTING PLATE
BLACK INDICATING FLUID
CALIBRATING PIN
DRAIN PLUGS
LOWER MERCURY ELEMENT

Schematic Arrangement of McNEILL LIQUID LEVEL GAGE *as Employed for High Pressure Boilers*

This diagram shows the simplicity of the McNeill Gage, together with the piping required. The Gage can be applied to your present water column, or directly to boiler drum.

T. W. McNEILL ENGINEERING EQUIPMENT CO.

Formerly Boiler Room Improvement Co. (Not Inc.)

4055 W. Van Buren Street

CHICAGO **ILLINOIS**

AGENTS IN PRINCIPAL CITIES

Manufacturers of
ECLIPSE SMOKE INDICATORS
and photo-electric recording, indicating and alarm systems.

Write for Bulletin SR-111 for information about smoke indicators.

Rehabilitate your plant with these and other Atlas Regulating Devices

Reducing Valves

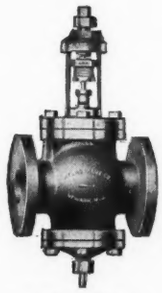


Fig. 104
Type A for Steam
Sizes from ½" to 10"

Both the type A and type B reducing valves are pilot operated, and will maintain a uniform reduced pressure, with a widely fluctuating initial pressure. Made for pressures from 25 to 600 lbs. saturated or superheated steam.

Ask for Bulletin, "Atlas Type A Reducing Valves."

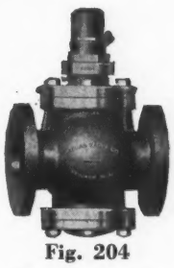


Fig. 204
Type B for Steam
Sizes from ½" to 10"

Type E water reducing and altitude valves are diaphragm operated, with balanced single seats and renewable composition discs. They shut-off tight and will keep the reduced pressure from climbing. Made for initial pressures from 1 to 250 lbs.

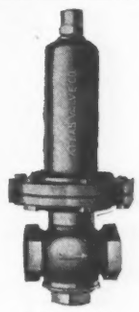
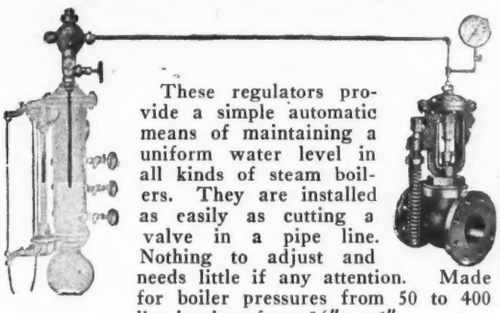


Fig. 304
Type E for Water or Air
Sizes from ½" to 10"

Campbell Feed Water Regulator



These regulators provide a simple automatic means of maintaining a uniform water level in all kinds of steam boilers. They are installed as easily as cutting a valve in a pipe line. Nothing to adjust and needs little if any attention. Made for boiler pressures from 50 to 400 lbs. in sizes from ½" to 6".

Ask for bulletin, "Campbell Feed Water Regulator."

Victor Damper Regulator

Fig. 503

A very sensitive regulator for maintaining uniform pressures. Ideal for boiler damper control, stoker or fan engine throttle control, electric speed regulators and lever operated steam reducing valves. Made in 3 sizes for controlling pressures from atmosphere to 450 lbs.

Ask for bulletin, "Victor Damper Regulators."

Pump Governors

Fig. 1-201
Ideal Style A
Sizes from ½" to 4"

The Ideal governor is operated by a piston in a bath of oil. Its simplicity has given it great success for many years in the marine field.

The Atlas type A governor is pilot operated and very sensitive in its action.

Both of these governors are used on all kinds of steam driven pumps to maintain a constant delivery pressure. Made for working pressure up to 450 lbs. and delivery pressures from 1 to 1,000 lbs.

Ask for bulletin, "Ideal Pump Governor."

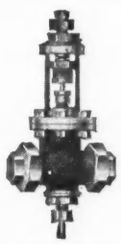


Fig. 202
Atlas Type A
Sizes from ½" to 4"

The Atlas type BD-HTS excess pressure pump governor is used to control the pressure delivered by direct acting or turbine driven boiler feed pumps. The Pilotrol, a device used to adjust these governors, has no adjusting springs; they will cause the governor to maintain the feed water at any desired pressure above the boiler pressure from no load to full load without hunting or surging. They are made for working pressures from 50 to 600 lbs.

Ask for bulletin, "Atlas Pump Governors and Float Valves."

Fig. 402
Atlas
Type
BD—HTS
Sizes
from
½" to 4"

Victor Temperature Regulator

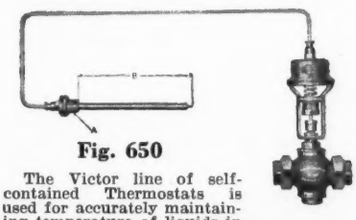


Fig. 650

The Victor line of self-contained Thermostats is used for accurately maintaining temperature of liquids in open and closed tanks, fuel oilheaters, condensers, gas coolers, retorts, etc. Also available for desuperheaters and numerous other applications. Sizes ranging from ½ to 8", inclusive.

Ask for bulletin, "Victor Temperature Regulators."

Atlas Lever Operated Control Valves

Fig. 230
Sizes from ½" to 6"

The maximum seat opening of these valves can be proportioned by the adjustable fulcrum on the lever, so that any Standard Control Device will give progressive increments of seat opening throughout its entire travel.

Ask for bulletin, "Atlas Lever Operated Control Valves."

Victor Pressure Regulator

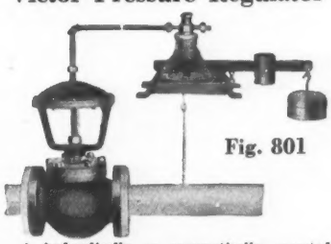


Fig. 801

A hydraulically or pneumatically operated pressure controller designed to maintain delivery pressures within a fraction of a pound, regardless of varying initial pressures or fluctuating loads. Suitable for controlling air, steam or gas pressure and particularly adapted for processing or other exacting service. Sizes ranging from ½ to 6", inclusive—for high and low pressure service.

Ask for bulletin, "Victor Super-Sensitive Pressure Regulator."

ATLAS VALVE COMPANY
REGULATING VALVES FOR EVERY SERVICE
289 SOUTH ST. NEWARK, N. J.

Badger Expansion Joints in a prominent processing plant.

Improvements in Expansion Joints brought out by Badger Engineers

●

Perfection of a practical method of forming corrugations to maintain a uniform thickness and eliminate manufacturing stresses.

Adoption of seamless copper tubes for Expansion Joints.

Adoption of equalizing rings for limiting flexing of individual corrugations.

Adoption of monel metal sleeves for protection against superheated steam.

Design of welding type joint. Earlier joints were all flanged.

Adoption of special copper to eliminate oxygen pockets within the metal.

Directed Flexing feature which distributes flexing stresses.

It is features such as these that led one steam utility to put several thousand Badger Expansion Joints in its lines.

Buy Your Expansion Joints as You Sell YOUR Products

You rely upon that soundest of all sales arguments—*experience with a record to back it up.*

Badger Expansion Joints have experience, plenty of it, back of them. They have a record of progressive improvement in utility. They stand today second to none in low-cost transporting of steam. They have long life and require no packing. They involve no maintenance. If you need expansion joints, don't overlook the proven *background* and *record* of the Badger Directed Flexing Expansion Joint.

E. B. BADGER & SONS COMPANY, 75 Pitts Street, Boston, Mass.

Atlanta, Ga., 140 Edgewood Ave.
Charlotte, N. C., Independence Bldg.
Chicago, Ill., 2831 S. Parkway.
Cincinnati, Ohio, 514 Main Street.
Cleveland, Ohio, Guardian Bldg.
Detroit, Mich., 702 Cadillac Sq. Bldg.
Houston, Tex., 1308 Sec. Nat. Bk. Bldg.
Indianapolis, Ind., 823 Occidental Bldg.
Kansas City, Mo., 1336 Oak Street.
Los Angeles, Cal., 812 Quinby Bldg.
Minneapolis, Minn., 732 Build. Exch.
Montreal, Que., Can., Cement Bldg.
New Orleans, La., 1666 Abundance St.
New York, N. Y., 271 Madison Ave.
Philadelphia, Pa., 1500 Walnut St.
Pittsburgh, Pa., Union Trust Bldg.
Salt Lake City, Utah, Kearns Bldg.
San Francisco, Cal., Sharon Bldg.
Seattle, Wash., Smith Tower.
St. Louis, Mo., 3605 Laclede Ave.
Tulsa, Okla., 409 East Archer Street

BADGER EXPANSION JOINTS

Thirty years ago this company was making one type of gasket. This gasket made good. From that one gasket there has developed a line of Akron Metallic Gaskets that today reaches around the world.

There are now different types of Akron Gaskets for every industrial requirement.

Result—a roll call of Akron metallic gasket users would include the finest central stations, the outstanding manufacturers and the best industrial plants in America.

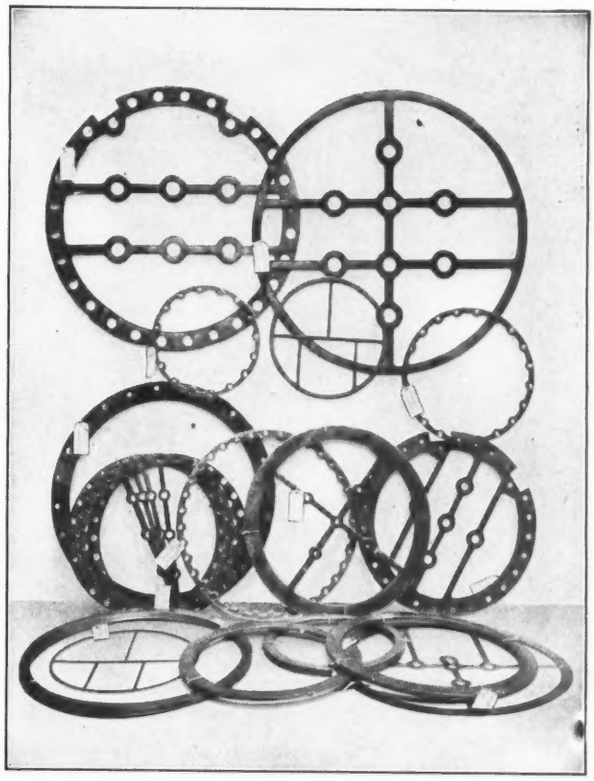
AKRON METALLIC GASKETS

★ ★ ★ 30 YEARS ★ ★ ★ IN THE POWER FIELD

The gasket shown above is our corrugated *Monel Metal Gasket* made for *high pressures*. Akron Gaskets are made in any size or shape or thickness, 1/4" to 24', of any metal or combination of metal and asbestos. Our catalog is well illustrated, showing sizes and dimensions. You need a copy—send for it now.

NOTICE

Akron corrugated Gaskets are fabricated from copper, monel metal, steel, iron, lead, bronze, aluminum, Akro-Metal, stainless steel, etc. Akron Asbestos Ribbed Gaskets have Asbestos cords cemented in each corrugation, made of any metal. Akron Solid Metal Gaskets are made of any thickness of any metal, in all shapes and sizes. Akron Metal Asbestos Gaskets are made in many different combinations, single and double shell types, both plain and corrugated, to meet varied conditions. Akron Metal Shell Asbestos Filled Gaskets for boiler tube caps, made of steel, copper, monel, and stainless steel. Akron Gaskets also made of asbestos, rubber, paper, cork, felt, fibre, compressed sheet packings, etc.

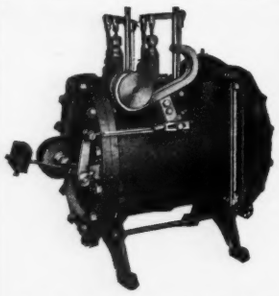


USE AKRON GASKETS—
THEY ARE BETTER

AKRON METALLIC GASKET CO.,

161 N. Union Street,
Akron, Ohio

(We appreciate your business)



The Sterling Boiler Feed or Lifting Pump is ruggedly constructed and will stand up and deliver dependable service with very little maintenance attention.

Sterling BOILER FEED **SYSTEMS**

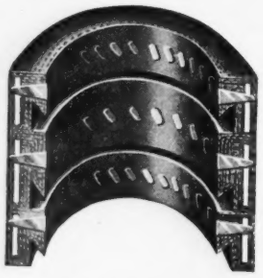
pay for themselves in a reasonable time

The Sterling System prevents heat losses by returning high and low pressure condensate directly to the boilers. It is simple, positive, and dependable in action. Power operators report that their cost records show the Sterling System pays for itself within a year through fuel savings. Please accompany your request for layout with memorandum of your problem.

STERLING ENGINEERING & MFG. CORPORATION

HYDE PARK ═══ **BOSTON, MASS.**

Energetic Sales Engineers needed in certain cities.



"Lion" Packing Is Also Made For Highest Steam Pressures.

WRITE FOR SAMPLES.

WALKER'S "LION" AUTOMATIC HYDRAULIC PACKING

PREVENTS LEAKAGE WITHOUT CAUSING FRICTION

Will Stand Highest Pressures

So constructed that the working pressure acts automatically on the lip, causing the packing to hug the ram or plunger, thus preventing leakage. *The heavier the pressure the tighter the packing.* Anti-friction metal pins, firmly anchored, maintain a continuous metal bearing face on the ram, reducing friction to a minimum. Requires little adjustment and always responds to working pressure.

Effective* • *Durable* • *Economical

In Coils or Rings to size of Ram or Plunger.

Mechanical Packings for all Purposes

THE JAMES WALKER PACKING CO., INC., 96 Liberty Street, New York, N. Y.

In 1896 - Lewis M. Ellison introduced to the power industry the original inclined tube gage —

ELLISON DRAFT GAGES

—this standard gage, the first of a distinguished line soon found quick recognition for supreme accuracy. "It's an Ellison," has come to mean excellence in construction and reliability in performance.

In order to better serve the power field the Ellison line has been developed during the past 38 years to include: **Pointer Draft Gages, straight line movement and dial type, Air Filter Gages, Saturator Gages, Liquid Level Gages, U. Gages, Pilot Tubes, Steam Calorimeters and Gas Analyzers.**

ELLISON DRAFT GAGES *The Entering Wedge To Boiler Room Efficiency*

ELLISON DRAFT GAGE COMPANY

214 West Kinzie Street Chicago, Illinois

THIS IS THE WAY POWER PLANTS *are* CUTTING COSTS!

10 DAY FREE TRIAL *will show* you

Ball Bearing

Clements Cadillac

Portable Electric Blowers

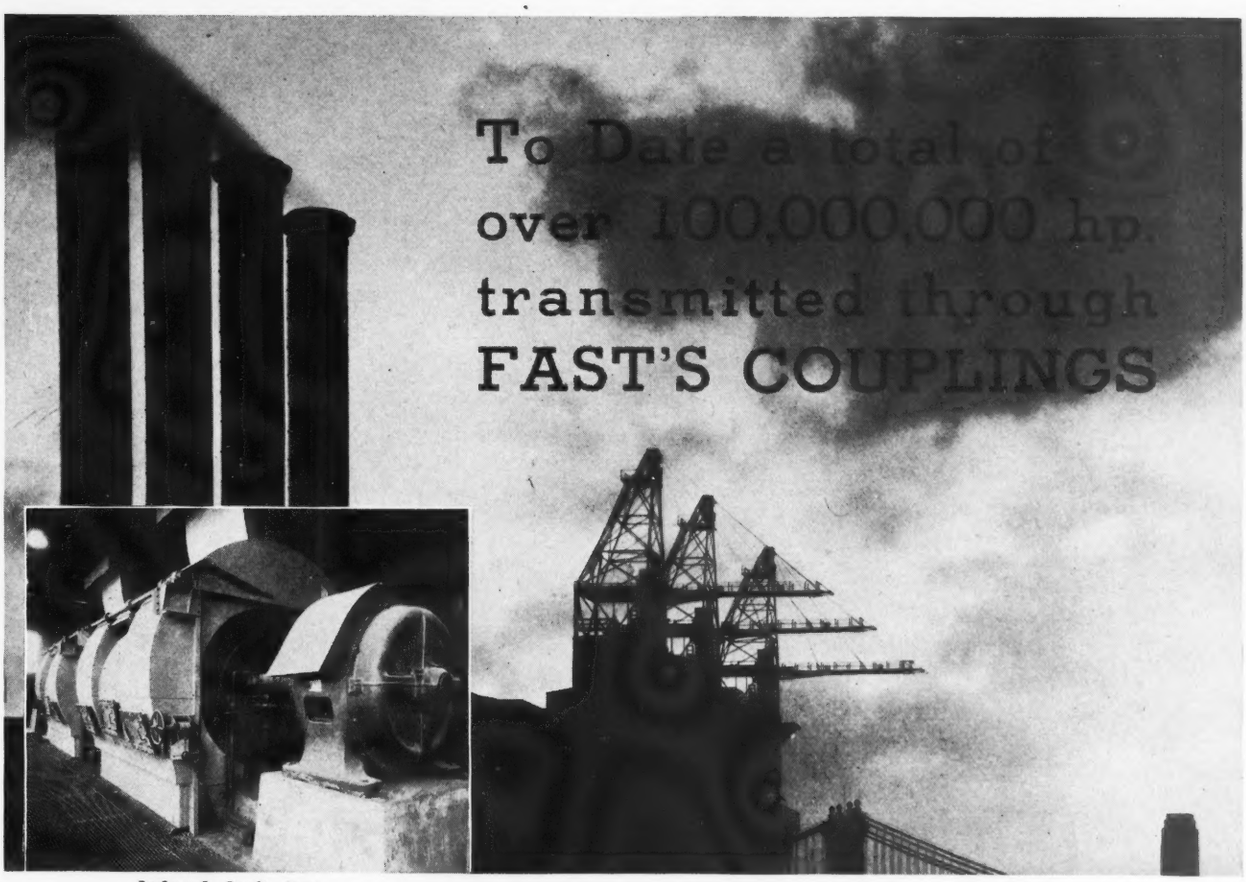
Try one—no installation costs—just plug into light socket — see how the Clements Cadillac will quickly pay for itself and actually make money for you by saving maintenance costs. It is safe and can be used on the most delicate or intricate equipment. You can use it for 10 days at no cost. Any voltage 110 to 275. Made in four models—write for details.

A simple, positive, dependable, and low cost method of keeping electrical equipment free from dust and dirt. Minimize fire risk. Prevent "shorts" and "burnouts." Regular use of the Clements Cadillac gives you all this economically. A stream of clean dry air at high velocity does the job quickly. More than 30,000 companies are using it. The Clements Blower is instantly convertible for suction cleaning of stock bins, etc. Attach to any light socket.

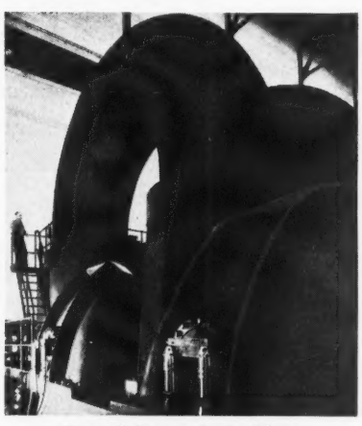
CLEMENTS MFG. CO.

6650 So. Narragansett Ave.

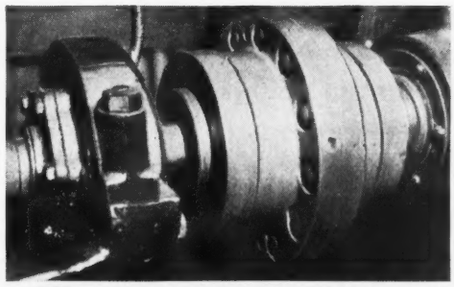
CHICAGO



Induced draft fans



One of the main turbines



FAST'S COUPLING which transmits 1,000 hp. at 1,200 r.p.m. on one of the induced draft fans

447,960 hp. at
HUDSON AVENUE STATION—

In this plant—representative of today's best power plant practice—FAST'S COUPLINGS transmit power ranging from 5 to 73,727 hp. on the most important drives—Main turbines—fan—pumps—in all 447,960 hp.

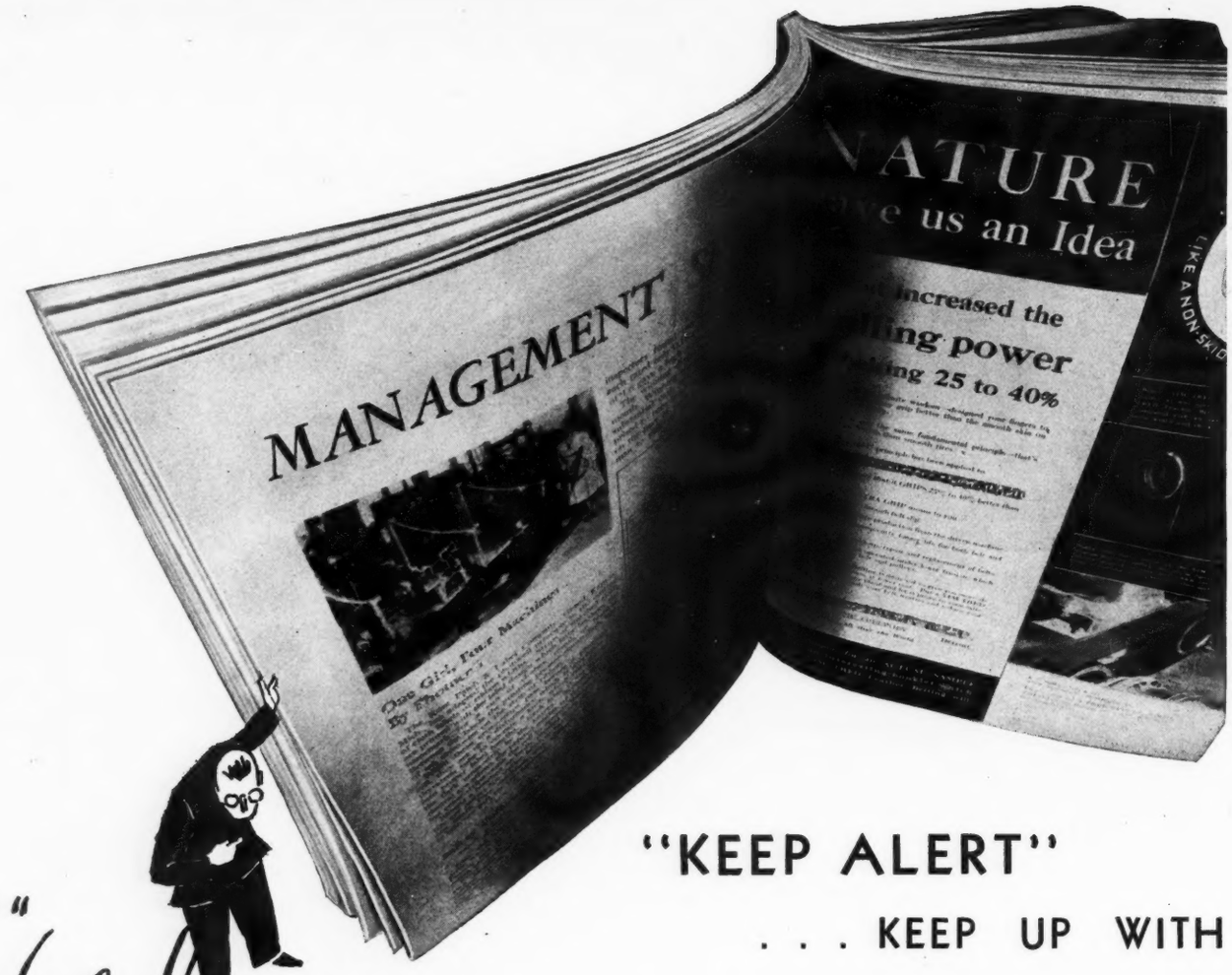
These modern couplings apply the same basic requirements for service that are demanded by other modern mechanical equipment; they protect shafts and bearings from injury due to misalignment, and they form a permanent method of transmitting power with a service life equal to that of the machines they connect.

These requirements for an ideal coupling have been service-proved by over 55,000 FAST'S COUPLINGS in operation today, aggregating a total of more than 100,000,000 horsepower.

Installations made over a period of 14 years have demonstrated the soundness and simplicity of the FAST PRINCIPLE which is purely mechanical, involving no rubber, leather, springs, discs or other flexible materials—a principle which has been found equally effective regardless of the amount of power transmitted.

Our engineers are available to help you fit FAST'S COUPLINGS to your requirements and insure a permanent solution to difficult drive problems.

The **BARTLETT HAYWARD CO., BALTIMORE, MD.**



"What's New"

BY THE EDITORS

"KEEP ALERT"

. . . KEEP UP WITH

Problems you face today cannot be solved with the methods of yesterday. Tomorrow may bring still other problems. The new competition is not only between products, it's between men.

The man who wants to lead, the man who is fighting for his business or his job, must know what is going on. Must know what's latest and best in methods, materials, machines. Must know the meaning of new rules, new laws, new Codes.

Your business paper is edited to help you in your job. To bring you the news of your industry. To *interpret* this news in terms of its effect on production costs, labor conditions, markets, competition and the other primary factors of business and industry. Your business paper has been giving special attention to the modernization of plant and equipment.

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BY THE ADVERTISERS

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It is a timely, important publishing job because every industry is struggling with the problem of producing reduced volume at lower unit costs.

Can you afford to be without the help your business paper's editors are offering you? Can you afford to miss the information that manufacturers are laying before you in the advertising pages? On your reading habits depend largely your chances for success. Keep up! *Keep alert!*

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FRANCE

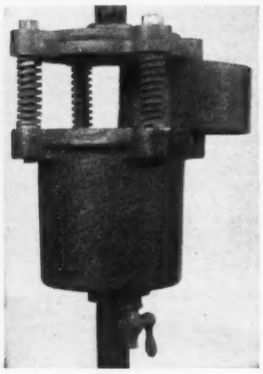
Metallic Packings of the better class

Ideal for superheated or saturated steam, ammonia, air or gas, for all pressures and operating conditions. Last 5 to 25 years. Sold on approval.

Write for catalog and list of users.

FRANCE PACKING COMPANY

6600 Tacony St., Philadelphia, Penna.



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EASILY CLEANED

A PROVEN FACT

Here is a *Filter* that will absolutely remove oil and water from your air lines as it does for these nationally known users:

ANHEUSER-BUSCH, INC.
LIGGETT & MEYERS TOBACCO CO.
STUDEBAKER CORP.
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BAILEY METER CO.
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U. S. GOVERNMENT
AMERICAN STOVE CO.
TITANIUM ALLOY MFG. CO.
CURTIS MFG. CO.
GENERAL CHEMICAL CO.
EASTMAN KODAK CO.

Send for complete information!

UNIVERSAL BOILER FILTER CORP.

Steam, Air and Water Filters

4223 Forest Park Blvd. — St. Louis, Mo.

For the Stranger at this "birthday party—"

THIS big number marks an occasion we're glad to have you celebrate with us—the fiftieth birthday of Power. If you are a non-subscriber, a power engineer who has seen this copy by chance, you are none the less welcome.

Indeed we are hopeful you decide to use Power regularly as a guide to new developments in your field.

The more "strangers" that join us the better for them and present subscribers. For the cooperative nature of Power makes every subscriber a potential contributor—there is a constant pooling of ideas and constructive comment for the benefit of all.

Every issue will bring you the new and important data on steam Generation—Power Generation—Water Power—Oil and Gas Engines—Heating and Ventilation—Refrigeration—Pumps and Compressors—Electricity and Elevators—Instruments and Control—Piping Systems—Mechanical Transmission—and all the power news.

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ANNIVERSARY ISSUE

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Also Serving the Power Plants of Every Industry

JUNE 1934

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Incorporated 1902
Lehigh and Fourth Streets
PHILADELPHIA, PA.
HOT and COLD PROCESS LIME SODA SOFTENERS
ZEOLITE WATER SOFTENERS
FILTERS OF ALL TYPES
CHEMICAL FEEDERS

QUAKER CITY RUBBER CO.
PHILADELPHIA, PA.
MANUFACTURERS OF
HOSE • BELTING
PACKING • VALVES
MOULDED GOODS

"CANTON" STOKER CORPORATION
Canton, Ohio
—Automatic Stokers—
Ram Type—Worm Type—Overfeed
For Boilers of 20 to 500 H.P.
Representatives in principal cities
Write for details.

The Frederick Iron & Steel Company
Frederick, Maryland
Centrifugal Pumps • Stokers
Ash Conveyors • Ash Bins
Gray Iron Castings • Couplings

S. Morgan Smith Co.
York, Pennsylvania
Manufacturers of
HYDRAULIC TURBINES

CEMENT GUN COMPANY
ALLENTOWN, PENNA.
Sole manufacturers of the "Cement Gun"
Use the "Cement Gun" for placing refractory materials in your boilers, etc., and allow our Contracting Department to line your coal bunkers and other steel structures demanding protection against fire and corrosion.

NATIONAL AIROIL BURNER COMPANY
1327 Girard Ave., Philadelphia, Pa.
Steam Atomizing Oil Burners, High Air Pressure Atomizing Oil Burners, Low Air Pressure Atomizing Oil Burners, Air-Turbine-Driven Rotary Oil Burners, Motor-Driven-Rotary Oil Burners, Mechanical-Pressure Atomizing Oil Burners, Gas Burners, Combination Gas and Oil Burners, Fuel Oil Pump Sets, Fuel Oil Heaters, Fuel Oil Strainers, Indicating Oil Firing Valves, Indicating Steam Control Valves, Furnace Windows.

STETS REGULATORS
"THAT'S ALL"
STETS CO. INC.
BOSTON

Everlasting Valve Co.
49 FISK STREET
JERSEY CITY, N. J.
OUR President and Founder, Mr. John H. Allen, also celebrates a golden anniversary this month—his 50th wedding anniversary, on June 17. And Everlasting Valves keep on giving long tight service.

PITTSBURGH PIPE COIL & BENDING CO.
BOILER TUBES, bent and straight, for all types of boilers.
PIPE BENDS PIPE COILS
67 Bridge Street
Etna Station, PITTSBURGH, PA.

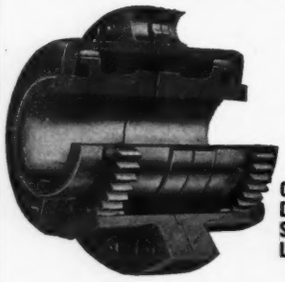
WRIGHT AUSTIN COMPANY
321 W. Woodbridge St., Detroit, Michigan
Steam Traps—Bucket and Float Types
Separators—Steam—Oil—Gas
Compressed Air Purifier
Exhaust Heads
Strainers
Alarm Water Columns
Trycocks
Water Gauges
"Inclinet" for present Water Gauge
Safety Protector for bursting gauge glasses
Send for the new literature.

POWER

ANNIVERSARY ISSUE — *SERVICE SECTION* — JUNE 1934

Machinery, Material, Equipment and Supplies for Power Plants

FLEXIBLE COUPLINGS



Oil-tight
Dust-proof
Self-Aligning
Lubricated

Send for our coupling catalog P-30, describing our full line of flexible couplings

Poole Foundry & Machine Co.
Woodberry, Baltimore, Md.

SAND-BANUM . . .

"The Always Effective Boiler Compound"

Sand-Banum actually controls boiler scale by preventing its formation and removes scale that has already formed. For years many of America's representative industries have standardized on Sand-Banum. It is an exactingly prepared concentrate, protected by U. S. and foreign patents; based on years of research in colloidal chemistry.

Sand Banum is a pure vegetable compound, guaranteed absolutely harmless to boiler, tubes, packings, etc.; guaranteed free from ammonia, graphite, water-glass, soda, lye, acid, potash or chloride, and is not carried over with the steam. Simple to use and applied only from 1 to 4 times monthly; delivered in cans of 16 fluid ounces, ready for use, requires no titrating or mixing of solution or special apparatus for application.

Booklet on request. We cordially invite your trial of Sand-Banum on our "No money down, satisfaction or it costs nothing" guarantee.

AMERICAN SAND-BANUM COMPANY, Inc.
342 Madison Ave., New York, N. Y.

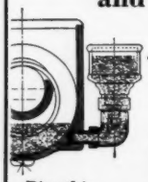
TURBINES

built to meet all conditions. We also build boilers of all types and sizes. Consult us before you buy.

Now in our 65th year of operation

MURRAY IRON WORKS CO.
Burlington, Iowa
Boilers—Engines—Generators—Turbines

Maintain Oil Level and end 75% of your Motor Troubles



SpeedWay Oilers

keep oil at exact level. Feed oil from reservoir *as used*. End oil dripping. Cut oiling time to fraction. Soon paid for in oil saved.

Pin this ad to your letterhead for 30-Day FREE TRIAL

SpeedWay Manufacturing Co.
1836 So. 52nd Ave., Cicero, Ill.

EXPLORE THE WONDERS OF GRAPHITE WITH DIXON'S GRAPH-AIR GUN

LUBRICATE IN NEW OILLESS, GREASELESS, PERMANENT WAY
with **DIXON'S New Microfyne (powdered) Graphite**
Won't burn, gum, drip—unaffected by water, oil, gasoline, alcohol, acids, alkalines and brine. Thousands of uses in factories, autos, homes and play.
Write for pamphlet 94-OG and name of dealer.
JOS. DIXON CRUCIBLE CO., Jersey City, N. J.
Established 1827
1 Novel nozzle control. 2 Handy burnisher attached. 3 More power from motors. 4 Lubricates locks. 5 For everything that slides.

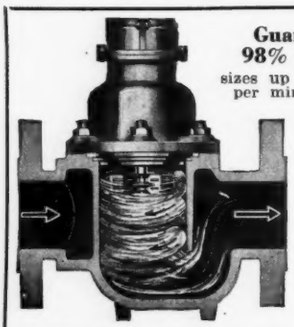
75¢ FILLED

NICHOLSON

WELDED STEEL FLOATS
CHROMIUM PLATED
AND
STAINLESS STEEL FLOATS

Good for pressures up to 2,000 lbs. Round sizes 3" to 12" in stock. Write for Bulletin No. 431. Inquiries on special floats solicited.

W. H. NICHOLSON & COMPANY
125 Oregon Street, Wilkes-Barre, Penna.



Guaranteed 98% accurate
sizes up to 600 gal. per min. capacity

HENSZEY METER

For boiler feed, blow down, dirty liquids, etc.

Goes right in the pipe line.

HENSZEY *Write for Catalogue*
DE-CONCENTRATOR CO.
WATERTOWN, WISCONSIN

TEST SPEEDS and SAVE at a glance
REVOLUTIONS and FEET per min
SPEED VARIATIONS
BELT SLIPPAGE
Send for Bulletin

O-Z Improved Hand Tachometer -Cutometer
O. ZERNICKOW CO.
21 Park Row, New York

— LEAKLESS COCKS —
GAGE GLASS GASKETS
that will fit and give service—"They won't blow out"
MASTER GAGE GLASSES
clear or magnifying red line for highest pressures
Write for descriptive circulars.
ERNST WATER COLUMN & GAGE CO., Newark, N. J.
SEE OUR OTHER AD. ON PAGE 188

NAUGATUCK SEAMLESS

COPPER BALL FLOATS
NAUGATUCK MFG. CO., Naugatuck, Conn.

POWER

ANNIVERSARY ISSUE — *SERVICE SECTION* — JUNE 1934

Machinery, Material, Equipment and Supplies for Power Plants

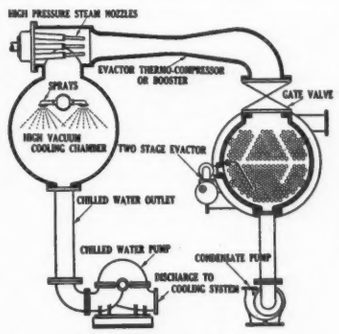
COLD WATER at

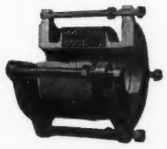
low cost *through evaporation*

The CHILL-VACTOR cools water to temperatures as low as 35° F., by evaporating a small percentage of the water in a vacuum created by steam jet apparatus as illustrated above. A logical further development of our steam-jet Evectors for power plants and chemical processes.

No moving parts—low first cost—low operating cost. Ideal for air conditioning, beer cooling and other present-day requirements.

Write us regarding any present or prospective cooling requirements. Illustrated bulletin and list of successful installations furnished promptly on request.





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"FLEXO-DISC" Expansion Joints do not break or leak. Elastic Alloy Steel "bellows type" Element replaces stuffing box and packing. Stainless steel when desired. Millions of movements without cracking or embrittlement. Sizes up to 30 inches. Hundreds of successful installations. Bulletin on request.

CROLL-REYNOLDS CO., INC., 17 John St., New York, N. Y.

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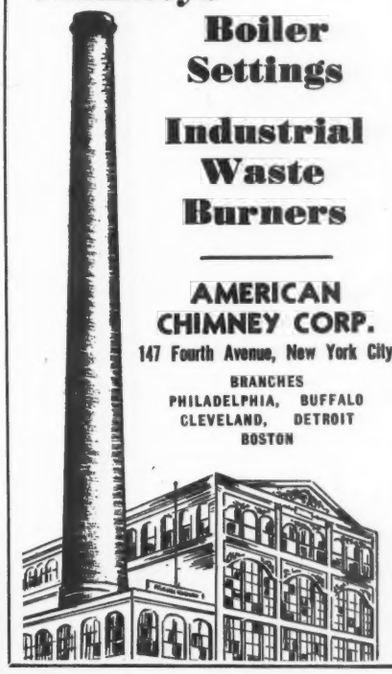
Boiler Settings

Industrial Waste Burners



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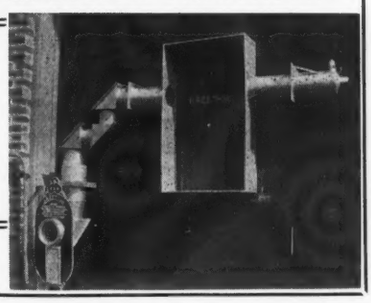
ACTUALLY visualizing the products of combustion as they pass out to stack—affording an educational study to firemen of gases, their color, rate of flow—and too much excess air. Observation haze screen mounted on panel, located on stoker fronts and in the firemen's most convenient line of vision. Note its flexibility. All fittings dustproof. Patented improvements by its inventor. Write the



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SIX—range.
25—30,000 r.p.m.
HAND TACHOMETER.
Bulletin 226-P.
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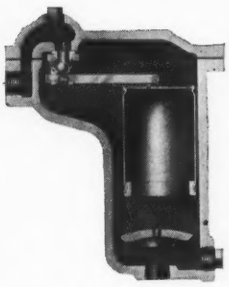

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For low steam trap maintenance use Cryer Inverted Bucket Steam Traps

Write for Bulletin

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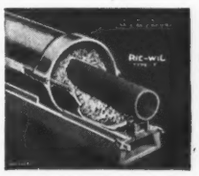

For underground steam lines

Only Ric-wiL has these advantages:
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AGENTS IN PRINCIPAL CITIES
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CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

CORRECT SPEEDS WITH *TACHOMETERS*
GEO. SCHERR CO.
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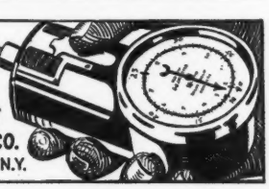
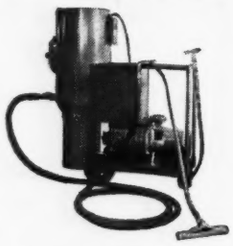


POWER

ANNIVERSARY ISSUE — *SERVICE SECTION* — JUNE 1934

Machinery, Material, Equipment and Supplies for Power Plants

PNEUMATIC CLEANING SYSTEMS



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Economical — Thorough — Sanitary

Portable and Stationary Systems—An ideal system for power plants, factories of all kinds—cleans floors, walls, ledges, rafters, overhead pipes, boiler tops, trusses, turbine rooms, motors—all types of machinery. No accumulations too hard to handle. Write for circular.

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Store Coal for a Few Cents per Ton

Sauerman Scraper Systems are adaptable to any problem of storing and reclaiming coal or other bulk materials. Capacities: 10 to 600 tons per hour. Write for catalog.

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Complete Stock—Quick Delivery

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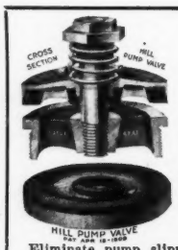

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HILL PUMP VALVE CO.

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330 W. 42d St., New York, N. Y. ?

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CONSULTING ENGINEERS
REFRIGERATION, POWER PLANT, BREWERIES

Industrial and Brewery Power and Refrigerating Plants, Air Conditioning, Ice Plants, Cold Storage Plants, Special Applications of Refrigeration.

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THE power plant executive who, with the help of sound engineering council, carefully scrutinizes every department of the plant with the result in mind of being thoroughly modern as to materials, equipment, operating methods, maintenance and management—that man is headed in the right direction.

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Industrial Water Conditioning
Corrosion Prevention

247 East 56th St., New York City

SEARCHLIGHT SECTION

JUNE 1934

POWER

ANNIVERSARY ISSUE

Employment—Equipment—Business Opportunities

Employment

POSITIONS VACANT

POWER PLANT TEST ENGINEER. Young mechanical graduate with at least two years' power plant experience wanted for position as test engineer in laboratory of large power plant in South America. Applicant must be thoroughly familiar with boiler testing and boiler water analysis. Give complete details—education, experience, age, married or single, and how soon available. Three-year contract, excellent living conditions, all traveling expenses paid. Address Desk 27, P. O. Box 47, Trinity Station, New York City.

EMPLOYMENT SERVICE

SALARIED POSITIONS, $2,500 to $25,000. This thoroughly organized advertising service of 24 years' recognized standing and reputation carries on preliminary negotiations for positions of the caliber indicated, through a procedure individualized to each client's personal requirements. Several weeks are required to negotiate and each individual must finance the moderate cost of his own campaign. Retaining fee protected by a refund provision as stipulated in our agreement. Identity is covered and, if employed, present position protected. If you have actually earned over $2,500, send only name and address for details. R. W. Bixby, Inc., 270 Delward Bldg., Buffalo, N. Y. (P.)

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CHIEF ENGINEER, 20 years' experience operation and maintenance of power, light and refrigeration equipment, open for position with utility, municipal or institution, plant. Middle Western location preferred. PW-342, Power, 330 West 42d St., New York City.

CHIEF ENGINEER, graduate mechanical engineer, 20 years' extensive experience in operation, maintenance and installation of industrial power plants. In present position I have reduced operation cost over 35%. Would like to hear from party with medium or large power plant who are not getting the desired results. I am married, age 42; would locate anywhere if conditions warrant. Present location New York. Salary expected, not under $4,000 per year plus bonus of effected savings. Available 30 days' notice. PW-358, Power, 330 West 42d St., New York City.

ELECTRICAL and mechanical maintenance, desire position with utility, municipal or industrial plant, experienced in handling maintenance and construction crews or can work alone. Experienced switchboard and turbine man. Best of references, will go anywhere. PW-356, Power, 520 No. Michigan Ave., Chicago, Ill.

REPRESENTATIVE AVAILABLE

Pacific Coast

Representation available for engines and power transmission machinery. Competent engineer with good record. Headquarters Los Angeles and San Francisco. RA-350, Power, 883 Mission St., San Francisco, Calif.

Sales Representatives Wanted

Nationally known Diesel Engine manufacturer desires aggressive agents to represent their line in exclusive territories. Most power users are prospects for sales. Good commission. When writing mention lines now handled.

RW-355, Power
330 West 42d St., New York City

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Steam, Gas, Oil and Electric

USED POWER EQUIPMENT

and Accessories

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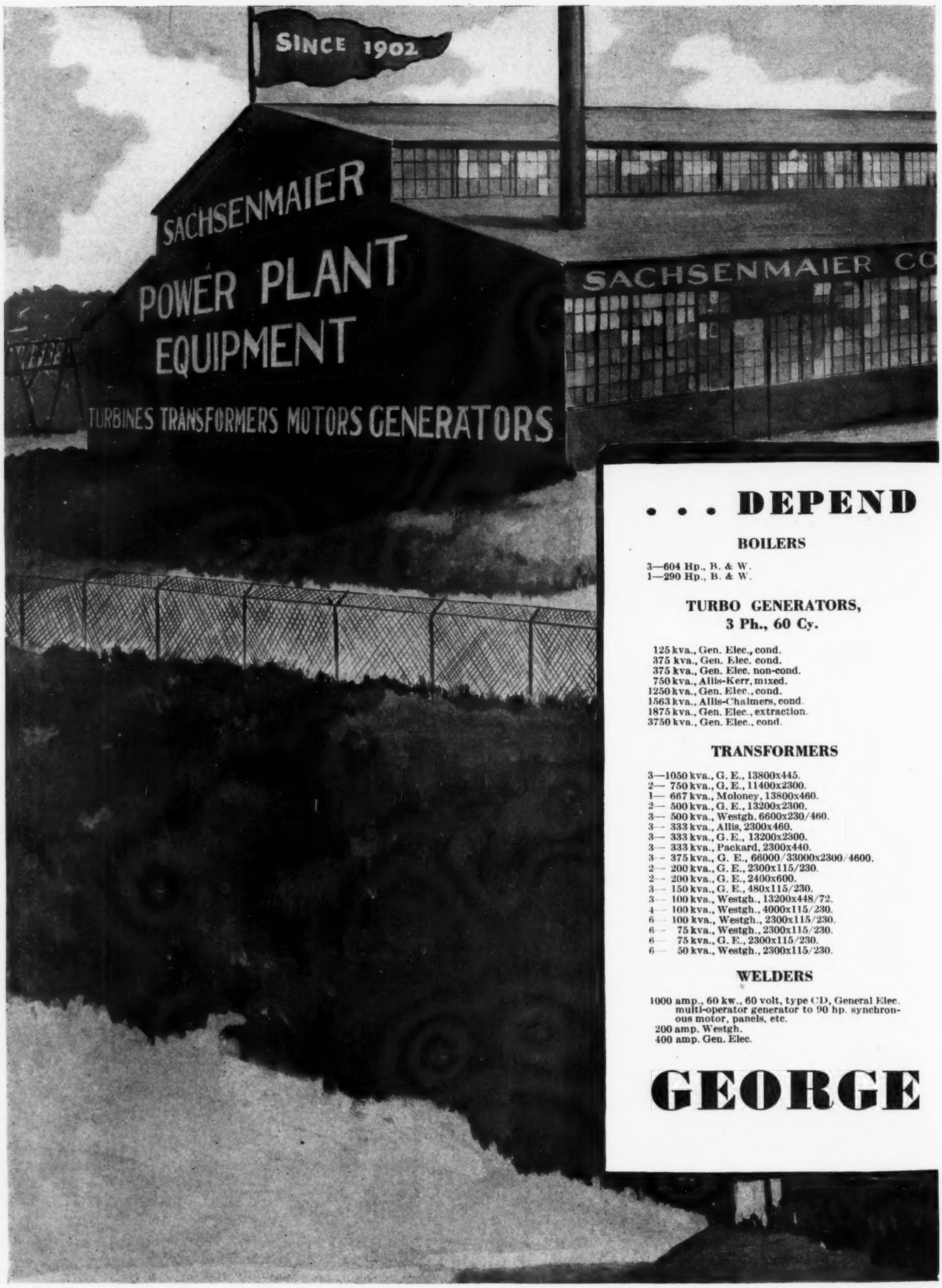

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BOILERS

3—604 Hp., B. & W.
1—290 Hp., B. & W.

TURBO GENERATORS, 3 Ph., 60 Cy.

125 kva., Gen. Elec., cond.
375 kva., Gen. Elec. cond.
375 kva., Gen. Elec. non-cond.
750 kva., Allis-Kerr, mixed.
1250 kva., Gen. Elec., cond.
1563 kva., Allis-Chalmers, cond.
1875 kva., Gen. Elec., extraction.
3750 kva., Gen. Elec., cond.

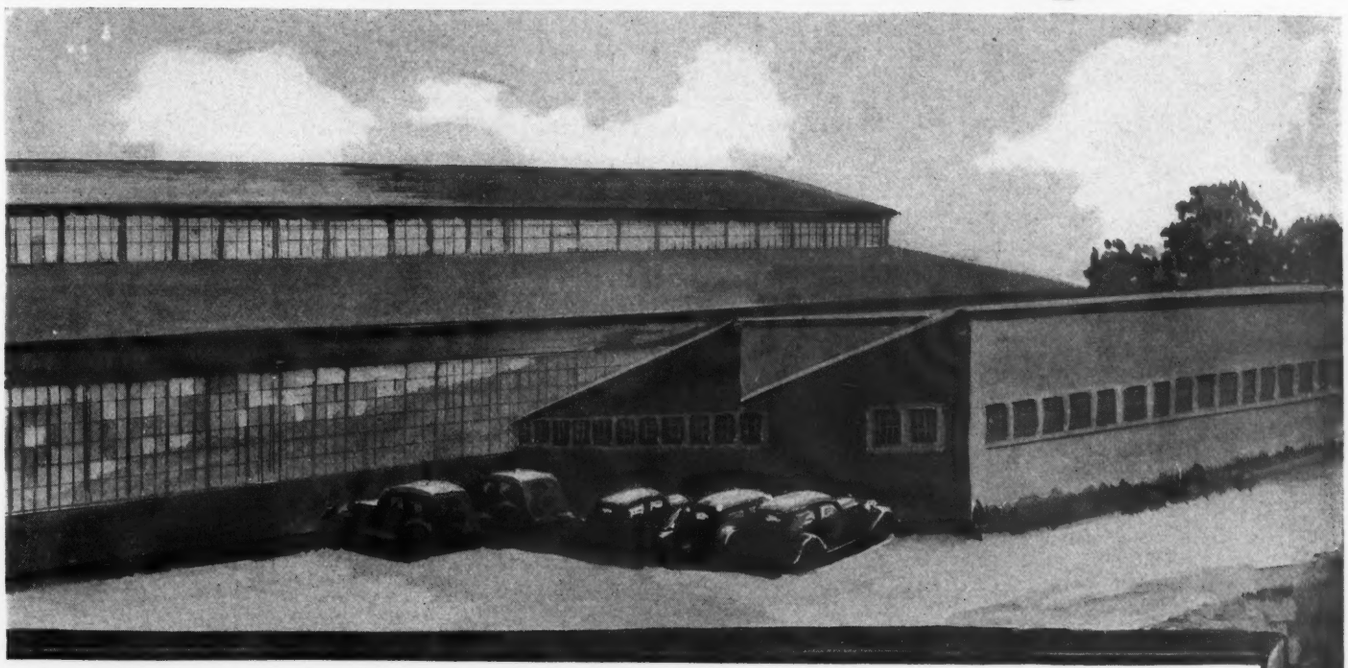
TRANSFORMERS

3—1050 kva., G. E., 13800x445.
2— 750 kva., G. E., 11400x2300.
1— 667 kva., Moloney, 13800x460.
2— 500 kva., G. E., 13200x2300.
3— 500 kva., Westgh. 6600x230/460.
3— 333 kva., Allis, 2300x460.
3— 333 kva., G. E., 13200x2300.
3— 333 kva., Packard, 2300x440.
3— 375 kva., G. E., 66000/33000x2300/4600.
2— 200 kva., G. E., 2300x115/230.
2— 200 kva., G. E., 2400x600.
3— 150 kva., G. E., 480x115/230.
3— 100 kva., Westgh., 13200x448/72.
4— 100 kva., Westgh., 4000x115/230.
6— 100 kva., Westgh., 2300x115/230.
6— 75 kva., Westgh., 2300x115/230.
6— 75 kva., G. E., 2300x115/230.
6— 50 kva., Westgh., 2300x115/230.

WELDERS

1000 amp., 60 kw., 60 volt, type CD, General Elec. multi-operator generator to 90 hp. synchronous motor, panels, etc.
200 amp. Westgh.
400 amp. Gen. Elec.

GEORGE



ABLE POWER EQUIPMENT . . .

MOTOR GENERATORS

500 kw., 600 volt, 3 ph., 25 cy., Westgh.
500 kw., 250 volt, 3 ph., 60 cy., Gen. Elec.
200 kw., 600 volt, 3 ph., 60 cy., Westgh.
100 kw., 250 volt, 3 ph., 60 cy., Westgh.
33 kw., 250 volt, 3 ph., 60 cy., Gen. Elec.

ROTARY CONVERTERS

300 kw., 250 volt, Westgh.
165 kw., 250 volt, Gen. Elec.
150 kw., 250 volt, Westgh.

DYNAMOMETER

300 hp., type TLC, Gen. Elec.

ENGINE GENERATOR UNITS

50 kva., 220-3-60, Ridgway
75 kva., 220-3-60, C. W. tc Harrisburg.
100 kva., 220-3-60, G E. to Skinner.
156 kva., 220-3-60, Allis to Skin.er.
250 kva., 440-3-60, G. E to Harrisburg.
400 kva., 220-3-60, Westgh. to Erie Ball.

D.C. MOTORS

Adjustable Speed—230 Volts

	Hp.	MAKE	TYPE	SPEED
1	225	Gen. Elec.	MPC	250/500
1	125	Gen. Elec.	CLC185	250/500
1	50/125	Electro Dynamic	SL20	1315/1750
1	65/75	Westgh.	SK170	575/1130
1	30/39	Gen. Elec.	RF13	395/1600
3	20	Gen. Elec.	CD113	400/1600
1	11.3/15	Westgh.	SK90	600/1200
1	10	Westgh.	SK	250/1000
1	8½	Westgh.	S5	780/1560
4	7½	Sprague	LC	1100/1500
1	6	Westgh.	SK40	750/1500
1	5	Electro Dynamic		550/1650
3	3½	Westgh.	SK40	450/1800
1	3½	Westgh.	SK50	375/1500
1	3-1½	Westgh.	SK23	850/1700
1	3	Northern		720/1400
1	3	Gen. Elec.	RF8	500/2000
1	3	Burke	5AB	850/1700
5	2½	Gen. Elec.	RA	400/1200

D.C. MOTORS (Cont.)

Adjustable Speed—230 Volts

	HP.	MAKE	TYPE	SPEED
2	2	Westgh.	SK23	700/2100
3	2	Westgh.	SK33	500/2100

Constant Speed—230 Volts

	HP.	MAKE	TYPE	SPEED
1	150	Gen. Elec.	RC19	800
1	125	Westgh.	SK180	700
1	100	Westgh.	SK180	625
1	100	Westgh.	SK160	1100
1	55	Allis-Chalmers		550
3	52	Gen. Elec.	RC35	850
1	50	West. Elec.	RC33	1075
1	50	Gen. Elec.	CLB	560
2	48	Gen. Elec.	RC15	850
1	40	Westgh.	S8L	825
1	40	Westgh.	SK140	775
1	40	Gen. Elec.	RC15	700
1	31.5	Gen. Elec.	RC12	1150
1	30	Gen. Elec.	RC31B	1150
1	25	Westgh.	SK103	1150
1	25	Westgh	SK	1400
1	25	Westgh.	SK120	825
1	25	Gen. Elec	RC13	775
1	25	Crocker-Wheeler	25I	750
1	20	Westgh.	SK	900
7	20	Westgh.	SK110L	750
1	20	Westgh.	SK70L	1700
1	20	Gen. Elec	RC12	800
1	20	Gen. Elec.	RC11	1150
1	15	Westgh.	SK90	825
1	15	Westgh.	SK	1200
2	15	Reliance	92TF	850
1	15	Gen. Elec.	CVC116	700
1	15	Gen. Elec.	RC30	850
2	10	Westgh.	SK	1750

A.C. MOTORS

3 Phase, 60 Cycle

	HP.	MAKE	TYPE	SPEED
1	225	Gen. Elec.	K	1200
1	200	Westgh.	CS	690
2	200	Fynn Welchsel	127RN35Y	720
1	152	Gen. Elec.	IM	720
1	150	Westgh.	CW	580
1	150	Westgh.	CS	900
1	150	Fairbanks-Morse	H20C	1800
1	125	Westgh.	CW	585
1	125	Gen. Elec.	IM	690

A.C. MOTORS (Cont.)

3 Phase, 60 Cycle

	HP	MAKE	TYPE	SPEED
1	125	Gen. Elec.	MT	1200
1	100	Westgh.	CS754C	870
1	100	Westgh.	CW866A	875
1	100	Westgh.	CS	1750
1	100	Gen. Elec.	IM	865
1	100	Gen. Elec.	IM	495
1	92.5	Gen. Elec.	ATI	900
1	75	Westgh.	CS	870
1	75	Westgh.	CW762C	900
1	75	Gen. Elec.	I-14	600
6	75	Crocker-Wheeler	124Q	690
1	75	Allis-Chalmers	AN	865
1	50	Westgh.	CW658A	855
2	50	Westgh.	CS	870
1	50	Gen. Elec.	MT327	1750
1	50	Crocker-Wheeler	65Y	850
1	40	Westgh.	CS	1170
1	40	Gen. Elec.	KT336	1165
1	40	Gen. Elec.	KT336	855
1	40	Allis-Chalmers	AN	865
1	30	Westgh.	CW636	1150
1	25	Westgh.	CS574A	870
1	25	Lincoln	DX413	850
3	25	Gen. Elec.	MT513	1720
2	25	Fynn Welchsel	19YRN	720
2	20	Westgh.	CS	860
1	20	Lincoln	DS8411	900
1	20	Gen. Elec.	KT322	865
1	20	Gen. Elec.	KT312	1150
1	20	Allis-Chalmers	AN	860
1	15	Westgh.	CS	680
1	15	Gen. Elec.	KT312	855
3	15	Allis-Chalmers	AN	1150
1	10	Wagner	BP17T	850
1	10	Wagner	BP14T	1720
1	10	Howell	SC	1800
2	10	Gen. Elec.	KT956	1160
2	10	Crocker-Wheeler	25Y	865
1	7½	Westgh.	CS354A	1140
6	7½	Gen. Elec	KT751	1160
1	7½	Gen. Elec.	FT944	1750
1	7½	Gen. Elec.	K284	1750
1	5	Westgh.	CS	675
1	5	Gen.Elec.to Gardner City Blower	KT936	1740
3	5	Allis-Chalmers		570

Partial List of our stock.
Please send us your inquiries and advise us of what you have for sale.

SACHSENMAIER CO., INC.

8403 Hegeman St., Holmesburg, Philadelphia, Pa.

Telephones: Palisade 2600-2601

A 3-WAY SERVICE SINCE 1921

1. Changeover and Construction—It has been our privilege to save some of the largest companies in the country money in changeovers from d.c. to a.c., 2 to 3 phase, 25 to 60 cycle.

In addition our facilities are available to undertake all kinds of electrical and power plant construction.

2. Rewinding and Rebuilding—This specialized branch of our service is based on a thorough understanding of motor construction and design. Our shop is equipped with modern coil making machinery to handle all sizes.

3. Equipment—Every item listed below represents outstanding value in equipment available for immediate service.—In view of the rapid turnover of our stock of used equipment, we suggest that you outline your requirements if you do not find your needs fully covered in the following lists.

MOTOR GENERATOR SETS

1—500-kw., 250-V., Westinghouse Synchronous motor Generator Set.
1—250-kw., 230-V., 3-ph., 60-cy., 2300-4600 Synchronous Motor Generator Set.
1—200-kw., 230-V., 3-ph., 60-cy., 2300-41-V Synchronous Motor Generator Set.
1—150-kw., 600-r.p.m., 250-V. Gen., 3-ph., 60-cy., 220-440-V. G. E. Synchronous Motor.
1—125-kw., 250-V., Westinghouse Synchronous Generator Motor Set 3-ph., 60-cy., 230-2200-V.
2—125-kw., 125-V., G.E., 2300-V. motor.
1—100-kw., 125-V., D.C., 220-440 A.C. G.E. Synchronous Motor Generator Set.
1—100-kw., 250-V., Gen., 900-r.p.m., 220-V. Synchronous Motor.
1—50-kw., 230-V., 1200-r.p.m., 220-V. Westinghouse Synchronous Motor.

FREQUENCY CHANGERS

2—200-kw., G.E., 25 cy., 6600 V., 60 cy., 440 V.

TURBINES

1—1500-kva., 3-ph., 60-cy., 2300-V., Condens. West.
1—750-kw., 3-ph., 60-cy., 480-V., Non-Condens., West.
1—475-kva. Westinghouse Non-conden.

TRANSFORMERS

4—333-kva. Pittsburgh, 4100/110/220-V.
6—200-kva. G.E., 2400/120/240-V.
4—150-kva. Westinghouse, 2400/120/240-V.
3—100-kva. Westinghouse, 2400/120/240-V.

A. C. GENERATORS

No.	Kw.	R.p.m.	Volts	Ph.	Type
1	125	900	2300	3	Cr.-Wh.
2	100	900	230-2300	3	G.E.
1	75	600	220	3	Westg.
1	75	900	2300	3	G.E.
1	50Kva.	450	220/440	3	Diehl

MOTORS—3 phase, 60 Cycle

No.	Hp.	R.p.m.	Volts	Type
1	1000	400	Any Voltage, sl. rg.	
1	800	180	4000	Westghse. Syn.
1	500	150	2300	Elec. Mach. Syn.
1	500	900	440/4000	Westghse. Syn.
1	500	450	2200	G.E., sl. rg.
1	350	900	2200/4000	Wh. Syn.
1	250	600	2200/4000	G.E. syn.
1	250	600	440/2200	G.E. syn.
3	200	450	2300/4100	G.E., sl. rg.
2	200	600	440	G.E., sl. rg.
1	150	360	2300	Allis Chal., Syn.
3	200	514	4150–2300	G.E. syn.
2	200	514	2300–4000	G.E. sl. rg.
2	150	1200	220/440	Westg., sl. rg.
1	150	900	2200	G.E. Syn.
2	150	514	2200	Westg., sl. rg.
1	150	1800	2200	West. sq. cg. mfr.

Complete Line of A.C. and D.C. Motors and Generators

SPECIAL—PRICED FOR IMMEDIATE SALE

2—UNIFLOW [Ames], 240 KVA., any voltage, modern units, in excellent condition

FOR SALE

AIR COMPRESSORS

2200 cu.ft. Ing.-Rd. PRE-2, 400 hp. Syn.
2—500 cu.ft. Ing.-Rd. 14"x10" ER-1, Belted.
2—386 cu.ft. Ing.-Rd. 12"x12" ER-1, Belted.
2—44 cu.ft. Ing.-Rd. 5"x4" ER-1, Belted.

MOTOR GENERATOR SETS

600 kw. G. E. 250 v. D.C., 2200 v., 3 ph., 60 cy., A.C. Syn. with panels.
500 kw. Westgh. 250 v. D.C., 4600 v., 3 ph., 60 cy., A.C. Syn. with panels.
300 kw. Westgh. 600 v. D.C., 2200 v., 3 ph., 60 cy., 80% P.F. Syn. with panels.
200 kw. Westgh. 250 v. D.C., 2200 v., 3 ph., 60 cy.
150 kw. Westgh. 250 v. D.C., 2200 v., 3 ph., 60 cy.

STEAM UNITS

2—937 kva. G. E.-Curtiss Turbo Units, 2300 v.
375 kva. G. E.-Curtiss Turbo Unit, 2300 v.
50 kva. Ridgway 240 v., 3 ph., 60 cy. Ridgway engine.
50 kw. Westgh. 250 v. D.C., Harrisburg engine.

A.C. and D.C. MOTORS

300 hp., 220 or 440 v., 3 ph., CW Westgh. 1800 r.p.m. slip ring with automatic control panel.
150 hp. Allis-Chalmers 2200 v., 3 ph., 60 cy., 1750 rev.
75 hp. G. E. 220 v., 3 ph., 60 cy. slip ring with control.
50 hp. Westgh. CW slip ring, 2200 v., 3 ph., 500 rev.
75 hp. Elec. Dyn. 230 v., 1700 rev. D.C.
50 hp. Westgh. SK 500 v., 750 rev. D.C.
30 hp. Westgh. SK 230 v., 1700 rev. D.C.

We carry a complete line of A.C. & D.C. Motors, Power Plant Equipment, Pumps, Hoists, Compressors and Coal Mining Machinery.

MOORHEAD-REITMEYER CO., INC.

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Power Plant Equipment

15 years of PROVED and approved service to a long list of satisfied customers, is evidence of the fact that our equipment met their requirements and expectations in

AIR COMPRESSORS,
BOILERS, PUMPS,
HEATERS,
ELECTRIC MOTORS,

MEMBER NATIONAL ASSOCIATION USED MACHINERY and EQUIPMENT DEALERS

ENGINE AND MOTOR GENERATOR SETS AND MACHINE TOOLS.

DELTA EQUIPMENT CO.
148 N. 3d St., Philadelphia, Pa.

GUARANTEED POWER EQUIPMENT

Air Compressors

Steam driven I.R.—10 865 CFM., two stg.—$700.
Belt driven—12x10 I.R 355 CFM., ER.-1.
Chgo. Pn. 9x8 NSB.—173 CFM.

Steam Generating Sets 3 60

125 kva. G.E., turbine—2300 V
75 kva. West—Ames. engine 240-480 V.
156 kva. G.E. Chuse 4 valve engine—240 480/2300 V.
Dir. Cur. 50 kw.—Northern—Chuse 250 V.
20 kw. Ridgeway 8x10—250 V.

Motors 3 Ph. 60 Cy.

Hp.	Type	Speed
1500	G.E. sl.rg.	514
275	Lincoln sl. rg.....	514
250	G.E. sl.eg.	514
220	G.E. syn.	900
200	West. sl.rg.	900
200	G.E. sl.rg.	514
200	G.E. sq.cg.	1200
150	G.E. sq.cg.	600
112	G.E. ITC	720
100	G.E. IK	1200
100	G.E. sl.rg.	600
85	West. CCL	600
75	West. MS	720

Our large stock includes your needs—WRITE TODAY—Join our family of smart purchasers.

ROCKFORD POWER MACHINERY CO.
631 Seventh Street Rockford, Ill.

Boilers

2—500 H. P. Stirling, 200 lb. pressure.
2—350 H. P. Stirling, 160 lb. pressure.
1—400 H. P. Edge Moor, 165 lb. pressure.
1—400 H. P. Keeler, 160 lb. pressure.
16—500 H. P. B. & W., 200 lb. pressure.
9—500 H. P. Heine, 200 lb. pressure.

Also other makes and sizes all A. S. M. E. fine condition. New and used.

J. F. DAVIS

20 N. WACKER DRIVE, CHICAGO, ILL.

RE-NU-BILT-GUARANTEED ELECTRIC POWER EQUIPMENT

Prompt Delivery—High Quality—Fair Prices

Centrifugal Pumps

Allis-Chalmers SF 20x18 14,000 GPM 150′ head 900 r.p.m. Casing and runner wearing rings—Casings built to stand 450′ total head—Double bottom suction nozzles, Horizontal side discharge. Direct connected to: Synchronous Motors—675 H.P. 504 K.W. 2200 volts, 900 R.P.M. 3 phase, 60 cycles. Direct connected exciters with Westinghouse Starting panels.

Type LS 20x20 14,000 G.P.M. 60′ head 720 R.P.M.—Casing and runner wearing rings. Horizontal side suction; Horizontal side discharge. Direct connected to: Synchronous Motors—260 H.P. 194 K.W. 100 P.F. 2200 volt, 54.6 amp. 60 cycles, 3 phase, 720 R.P.M., Direct connected exciter equipment similar to above. Pump and Motor mounted on common C.I. Base.

Above equipment purchased new 1930, only used a few months, now in first class condition showing practically no signs of wear.

Pumps

1—2500 G.P.M. DeLaval Type P 10, 159 ft. 75 lbs. 10″ single stage double suction direct connected to:
150 H.P. G.E. type KT motor, 1750 R.P.M. 220 volt, 3 phase, 60 cycle with control.

2—700 G.P.M. W'thl'ton., 3 stage size 5 SD, turbine pump 120 lbs. 6″ intake 5″ discharge, good for 700 G.P.M. against total head of 382 ft. about 190 lbs.

Transformers

4—500 K.V.A. Westinghouse O.I.S.C. P 2400 volts, S 240/120 Volts, single phase, 60 cycle with high voltage percentage taps.

Motor Generator Sets

750 K.W., G.E. Type MPC, 250 V. D.C. Gener. Dir. Conn. 1100 H.P., G.E. ATI, Synchr. motor, 2200 V., 3 Ph., 60 Cy., 900 R.P.M. Fully complete with all control equipment.

200 K.W. Crocker Wheeler, Type 149 DA, com'd. interpole, 250 V., dir. conn. 300 H.P. Ind. motor, 2300/220 V., 3 Ph., 60 Cy., 575 R.P.M. Complete with all control equipment.

150 K.W., Cr. Wheeler Size 81H, Comp'd. Interpole, 125 V. D.C. Dir. Conn. 225 KVA. 80% P.F. Synch. Motor 220/440 V., 3 Ph., 1200 R.P.M., 60 cy. complete.

150 K.W., Cr. Wheeler, Type CCD, com'd, interpole, 250 V. dir. conn. 250 H.P. G.E. synchr. motor, ATI, 220/440 V., 3 Ph., 60 Cy., 900 R.P.M.

Motor Gen. Sets (Con't)

90 K.W. G.E. Set: 3 bear. consisting of 90 K.W. Type DLC-206, D.C. Gen. 110 volt, 900 R.P.M., comp'd Interpole, dir. conn. to 139 H.P. Synch. Motor, 2300/230 volt, 900 R.P.M., 3 ph., 60 cy.

50 K.W. G.E. Set, D.C. Type RC-15, 125 V. coupled to 75 HP. KT-547, Sq. cage, 220 V., 3 ph. 60 cy. 1150 R.P.M.

Steam Generator Sets

1—85 KVA 220 V. 3 ph. 225 R.P.M., 60 cy. Cr. Wheeler AC Gen. Dir. conn. Sturtevant 14″x14″ S.V. 100 lbs. S.P.

1—400 KVA, 240 or 480 Volt, 60 cy. Cr. Wheeler AC Gen. Dir. conn. simple Hamilton Corliss 20″x36″ mounted on C.I. Base, complete unit.

Gasoline Eng. Gen. Sets

2—25 KW. G.E. Type GM-12 4 cy. Gas eng. Dir. conn. 125 V. DC comp'd int., complete with tank, rad, mag. S/B, etc. units mounted on standard truck trailer.

1—12 KW. 125 V. DC Star Ballbear, dir, conn. Buffalo Gas Eng. Type CA.

1—50 KW. 125 V. DC West, comp'd int. Gen. 1200 R.P.M. dir. conn. 80 HP. Sterling Gas Eng. Type FC-4. Complete with starter, Mag.

Note: Can furnish AC Gen. Can mount truck type trailer.

Diesel Eng. Generator Sets

1—30 KW. 115 V. DC Ideal Gen. dir. conn. 48 HP. Cummins Diesel model U. both units mounted on C.I. Base.

1—200 HP. McIntosh & Seymoore, 8 cy. V-type Diesel 500 R.P.M. Dir. Conn. 135 KW. DC. G.E. Gen. Note: Can Furnish A.C. Gen.

A.C. Motors

Synchronous Type
3 phase, 60 cycle

H.P.	Make	Type	Volts	Speed
1—1500	G.E.	ATI	2200	240
3— 675	Al. Ch.		2200/550	900
1— 600	G.E.	ATI	2200/550	257
1— 260	Al. Ch.		2200/440	720
1— 200	G.E.	ATI	2200/440	900

Slip Ring Type

H.P.	Make	Type	Volts	Speed
1—800	G.E.	IM	2200	720
2—600	G.E.	MT-542Y	2300/550	257
1—500	Al. Chal.	ANY	550	505
1—400	West.	CW	2300	514
1—300	Al. Chal.	ANY	2200	585
1—250	West.	CW	2200/440	720

Slip Ring Type (Cont.)

H.P.	Make	Type	Volts	Speed
1—200	West.	CW	440	500
1—200	G.E.	MT-557Y	220/440	1800
1—150	G.E.	I-E13AA	440	1750
1—100	G.E.	MTC	220/440	860
1—100	Wagner	BR	220	850
1— 90	Wagner	BR	220/400	650
1— 75	G.E.	MT	220/550	690
1— 75	Burke	EMV	2200	450
1— 75	G.E.	M	440	1200
1— 60	G.E.	M	220/440	900
1— 50	West.	CI	220/440	690
1— 50	West.	MW	440/220	580
1— 50	G.E.	MIS	220	1200
1— 40	West.	CW	2200	1160
1— 35	G.E.	MTC	220	585
1— 30	West.	CW	220	1160
2— 30	West.	CW	440/220	1800

Squirrel Cage Type

H.P.	Make	Type	Volts	Speed
1—300	Cr. Wh.	AQ	2300/220	580
1—200	West.	CS	220/440	580
2—125	West.	CS	220/440	900
2—100	West.	CS	550	720
1—100	West.	CS	220	700
1— 75	West.	CS	220/440	870
1— 60	G.E.	KT	2200	1760
2— 50	G.E.	KT	220/440	870
1— 50	Al. Chal.		550	1750
1— 50	West.	CS	440/220	1800
1— 40	West.	CS	440/220	1800
3— 20	G.E.	KT	220/440	900

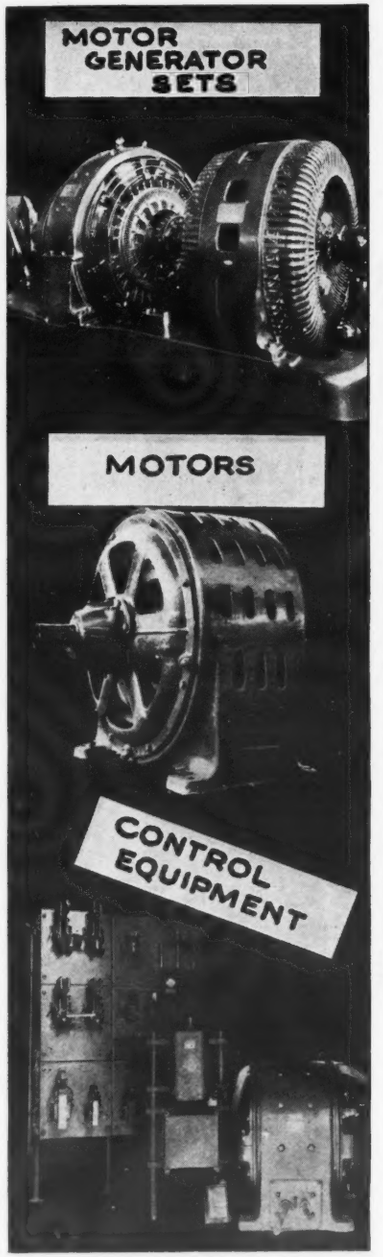
D.C. Motors

Adjustable Speed—230 Volts

H.P.	Make	Type	Speed
1—100	West.	SK-200	365/600
1—100	West.	SK-180	475/950
2— 75	West.	SK-210	200/600
1— 50	West.	SK-190	225/600
1— 35	West.	SK	500/1500
1— 35	Cr. Wh.	CMC	800/1600
1— 35	West.	SK-160	350/1050
1— 30/40	El. Dyn.	30-S	210/840
1— 25	West.	SK	400/1200
1— 20	G.E.	CD-95	850/1700
4— 20	West.	SK	375/1500
27—20	G.E.	LC	650/1950
25—10	West.	SK-90	500/1500

Constant Speed—230 Volts

H.P.	Make	Type	Speed
1—200	Cr. Wh.	CCD	600
1—150	G.E.	CD-169	450
1—125	Shaw	Series	410
1—100	West.	SK-180	625
1—100	Sprague	D	425
1— 75	G.E.	CO-1831	500
1— 40	G.E.	RC-34	860
1— 50	G.E.	LC	1750
1— 50	West.	SK-150	750



RE-NU-BILT BELYEA MOTORS

BELYEA CO., Inc.

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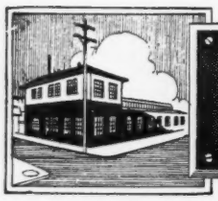
RE-NU-BILT BELYEA MOTORS



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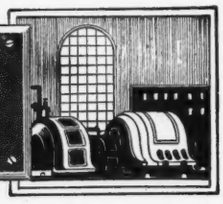

SLIP RING MOTORS,

3-PH., 60-CY.

HP	Volts	Make	Speed
700	2300	G.E.	900
220	220–440	G.E.	450
200	440–220	G.E.	600
150	2200–440–220	G.E.	514
150	2200–220–440	G.E.	720
150	220–440–550	G.E.	600
100	220–440	G.E.	450
100	2200–440–220	Westghse.	1200
100	550	Wagner	720
100	2200–550	Westghse.	900
100	440–220	G.E.	720
100	550	G.E.	900
75	440–220	G.E.	900
50	2200	G.E.	514

SYNCHRONOUS MOTORS,

3-PH., 60-CY.

300	220–440	G.E.	600
240	2200–440–220	G.E.	600
172	2200–440–220	G.E.	720
160	2200–440–220	G.E.	600
120	2200–550	G.E.	900

A.C. GENERATORS

1—250 kva., 600 r.p.m., 240-480-V., G.E.
1—225 kva., 600 r.p.m., 2200-240-480-V., G.E.
1—112 ½ kva., 1200 r.p.m., 2300-240-480-V., G.E.
1—112 ½ kva., 900 r.p.m., 2200-240-480-V., G.E.
1—62 ½ kva., 1200 r.p.m., 480-240-V., G.E.
1—50 kva., 1200 r.p.m., 2300-480-240-V., Whse.
1—37 ½ kva., 1200 r.p.m., 480-240-V., G.E.
1—30 kva., 1200 r.p.m., 2300-480-240-V., Whse.

MOTOR GENERATOR SETS

1—225-kw., 125-V., 1200 r.p.m., G.E. MPC connected to ATI, 2300 V., 60 cy., syn. motor.
1—200-kw., 250-V., 1200 r.p.m., Reliance connected to El. Mach. 2400/4150-V., 60 cy. syn. motor.
1—150-kw., 250/125-V., 3 wire, 900 r.p.m., Whse. SK. connected to Whse. 2400/4150 V., syn. motor.
1—50-kw., 125-V., 1200 r.p.m., Reliance con. to El. Mach. 2300/440/220 V. syn. motor.
1—25-kw., 125-V., 1800 r.p.m. G.E. RC con. to KT 40 HP., 440/220 V. motor.
1—15-kw., 125-V., 1800 r.p.m. G.E. RC con. to KT motor.
1—5 ½-kw., 125-V., 1800 r.p.m. G.E. CD con. to KT motor.

DIRECT CURRENT MOTORS

HP	Volts	Make	Type	Speed
250	230	G.E.	MPC	700
200	230	G.E.	RC	800
125	230	G.E.	RC	850
100	230	Westghse.	SK	625
100	230	G.E.	LC	1150
80	230	G.E.	RC	600
75	230	G.E.	RC	950
50	230	G.E.	CD	1150
50	115	G.E.	DLC	565
40	230	G.E.	RC	750
25	115	Westghse.	SK	825

ENGINE GENERATOR SETS

2—Crocker-Wheeler 50 kw., 240 V., 275 r.p.m. con. to 12"x14" Erie Ball side crank engines.

SQUIRREL CAGE MOTORS

HP	Volts	Make	Type	Speed
150	550	G.E.	KT	720
100	550	G.E.	KT	900
100	440–220	G.E.	I-K	720
100	220–440	G.E.	KT	1200
100	220–440	G.E.	KT	900
75	220–440	G.E.	KT	720
75	2200	Westghse.	CS	1800
75	220–440	G.E.	I-K	450
60	220–440	Westghse.	CS	1800
50	4000–2300	G.E.	I-K	900

TRANSFORMERS

60 CYCLE

3—250 kva., G.E. type H-KDD 13800-230/460 V.
6—200 kva., G.E. type H-KS 2300/4000 Y-230/115 V.
2—200 kva., G.E. type H-KS 2200-220/440 V.
3—150 kva., Allis-Chalmers type ODSC 13800-230/460 V.
3—150 kva., G.E. type H, 2300-230/115 V.
3—75 kva., Pittsburgh 2300/6900-230/460 V.
3—75 kva., Whse. type SK 2200-440/220 V.
3—75 kva., Whse. type SKA 2300-115/230 V
1—75 kva., G.E. type H-KS 4800/2400-240/208/120 V.
6—50 kva., G.E. type H-KS 2200-220/110 V.
6—37 ½ kva., Whse. type S 2200-220/110 V.
3—25 kva., G.E. type H-KR 13800-230/460 V.
1—5 kva., G.E. type H 26400-115/230 V.

VOLTAGE REGULATORS

1—Whse. type AL3, 100/120 V., AC 45/135 exciter volts, complete.
2—Whse. type AB1, 100/120 V., AC 45/135 exciter volts, complete.

SOUND VALUES

3—4000 kw., 2300 v. A.C. G.E. Turbines.
2—750 kw., 2300 v. A.C. G.E. Turbines
1—300 kw., 2300 v. A.C. G.E. Turbine.
1—360 kw., 480 v. A.C. G.E. Ames Uniflow Unit.
1—300 kw., 240 v. A.C. Ridgway 4 valve C.C. engine unit.
1—400 kw., 2300 v. A.C. G.E. Rathbon Jones natural gas unit.
1—150 kva., 3 ph., 60 cy., 2200 v. A.C. Westinghouse type "LD" capacitor.
1—125 kva., .8 P.F., 230 v. A.C. Fairbanks belted Gen. exciter and switchboard.
1—50 kva., .8 P.F., 230 v. A.C. Fairbanks belted Gen. exciter and switchboard.
1—1000 kw., 550 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Westinghouse synch. m. g. set.
1—600 kw., 250 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Gen. El. synch. m. g. set.
2—300 kw., 250 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Gen. El. synch. m. g. sets.
1—200 kw., 250 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Gen El. synch. m. g. set.
1—150 kw., 250 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Gen. El. synch. m. g. set.
1—100 kw., 250 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Westinghouse synch. m. g. set.
2—75 kw., 250 v. D.C., 3 ph., 60 cy., 220/440 v. A.C. Westinghouse Induction m. g. sets.
1—50 kw., 250 v. D.C., 3 ph., 60 cy., 220/440 v. A.C. Westinghouse Induction m. g. set.
1—150 kw., 125 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Burke synch. m. g. set.
1—100 kw., 125 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Gen. El. synch. m. g. set.
1—100 kw., 125 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Westinghouse Induction m. g. set.
1—65 kw., 125 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Westinghouse Induction m. g. set.
1—50 kw., 125 v. D.C., 3 ph., 60 cy., 2300 v. A.C. Westinghouse Induction m. g. set.
1—50 kw., 125 v. D.C., 3 ph., 60 cy., 440/2300 v. A.C. Westinghouse synch. m. g. set.
2—2500 hp., 3 ph., 60 cy., 2300 v., 200 r.p.m. Westinghouse synch. motors.
1—1200 hp., 3 ph., 60 cy., 2300 v., 295 r.p.m. G.E. slip ring motor.
2—700 hp., 3 ph., 60 cy., 2300 v., 400 r.p.m. G.E. slip ring motor, 3 brg.
4—500 hp., 3 ph., 60 cy., 2300 v., 450 r.p.m. G.E. slip ring motors, 3 brg.
7—400 hp., 3 ph., 60 cy., 2300 v., 500 r.p.m. Westinghouse slip ring motors, 3 brg.
3—2000 kva., 24000/2300 v. G.E. 1 ph., 60 cy. transformers.
1—150 hp., 3 ph., 60 cy., 220 v., 900 r.p.m. G.E. .8 P.F. synch. motor.
1—325 hp., 3 ph., 60 cy., 2300 v., 514 r.p.m. Westinghouse .8 P.F. synch. motor.

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400 K.V.A. C. W.—Hamilton
312 K.V.A. G. E.—Chuse Uniflow.
250 K.V.A. Al.-Chal.—18x36 Al.-Chal.
250 K.V.A. G. E. Skinner Uniflow.
200 K.V.A. G. E. Erie Ball 4 v.
180 K.V.A. G. E.—Chuse Uniflow.
125 K.V.A. Wghse.—Skinner Uniflow.
120 K.V.A. G. E. Erie Ball 4 v.

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4000 K.V.A. (2) Al.-Chal. Condensing.
1875 K.V.A. (2) G. E. Non-condensing
1250 K.V.A. G. E. Bleeder.
937 K.V.A. G. E. Condensing
750 K.V.A. Wghse. Mixed Pressure.
625 K.V.A. Wghse. Condensing.
600 K.V.A. G. E. Non-condensing.
375 K.V.A. Wghse. Mixed Pressure.
375 K.V.A. G. E. Non-condensing.
250 K.V.A. Al.-Chal., Kerr Mixed Pressure.
187 K.V.A. Wghse. Non-condensing.
125 K.V.A. G. E. Non-condensing.

BOILERS

605 H.P. Springfield 165 lb.
500 H.P. (4) Edgemoor 200 lb.
400 H.P. (3) Heine 200 lb.
350 H.P. Heine 175 lb.
300 H.P. B & W 175 lb.
256 H.P. Sterling 160 lb.
250 H.P. (3) Heine 180 lb.
150 H.P. (3) Economic 125 lb. Nat. Board.

UNITS (D.C.)

500 K.W. G. E. 250 v. Erie Ball 4 v.
250 K.W. G. E. 250 v. Harrisburg Uniflow.
200 K.W. Al.-Chal. 250 v. Al.-Chal. Co.
200 K.W. Wghse. 250/125 v. Turbine.
100 K.W. C. W. 250 v. Erie Ball 4 v.
150 K.W. (2) G. E. 125 v. Harrisburg Unif.
50 K.W. G. E. 250/125 v. Ames.

M. G. SETS

400 K.W. G. E. 250 v.—G. E. 2200 v. syn.
500 K.W. Wghse. 250-4000/2300 v. syn.
200 K.W. Al.-Chal. 250 v., 440 v. syn.
50 K.W. G. E. 250 v., 240 v. syn.

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300 hp. Allis-Chalmers slip ring motor, 60 cycle, 3 phase, 4400/2200 volts, 1200 r.p.m., base and pulley.

700 hp. General Electric, slip ring motor, 60 cycle, 3 phase, 4400/2200 volts, 900 r.p.m., base and pulley.

WANTED FOR CASH

1—300 hp. Synchronous motor, 25 cycle, 3 phase, 550 or 2200 volts, 750 r.p.m., direct connected to 230 volt D.C. Generator, 250 kw. complete with control panel.

1—30 hp. General Electric motor, type KT, 537, 25 cycle, 3 phase, 220 volts, 750 r.p.m.

1—150 hp. motor, 25 cycle, 2 phase, 2200 volts, 500 r.p.m., or slower, bare or complete.

1—300 hp. motor, 60 cycle, 3 phase, 2200 volts, 1800 r.p.m., complete.

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1—200 hp. Westinghouse CW, 500 r.p.m. slip ring 440 v.
1—150 hp. G. E. Type 1, form M, 435 r.p.m. slip ring 440 v.
1—125 hp. Allis-Chalmers, 435 r.p.m. slip ring 2200 v.
4—75 G. E. Type 1, form M, 600 r.p.m. slip ring 2200 v.
3—50 G. E. MT, 600 r.p.m. slip ring 2200 v.
1—75 Westinghouse CW, 870 r.p.m. slip ring 2200 v.
1—50 G. E. MT, 900 r.p.m. slip ring 2200 v.
Complete control equipment with all.
3—G. E. 250 kw. 2200/6600/230/460 transformers, 1 ph., 60 cy.
3—G. E. 300 kw. 6600/13200/2300 transformers, 1 ph., 60 cy.
3—West. 125 kw. 2300/240/440 transformers, 1 ph., 60 cy.
3—G. E. 200 kw. 2200/6600/230/460 transformers, 1 ph., 60 cy.
All above completely overhauled—guaranteed.

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Your inquiries earnestly solicited.

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Scranton, Pa.

Complete Power Plant and Other Equipment

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1—Motor Driven McGowan Centrifugal Pump, 35-hp., CCL, West. Motor, 3 ph., 60 cy., 220 v., 1700 r.p.m., Allen Bradley Starter.
1—Motor Driven DeLaval Cent. Pump, 75-hp., G. E. Motor, Type I—220 v., 3 ph., 60 cy., 1800 r.p.m. Pump—Type 2P4, 2 stage with starter.
1—Motor Driven Double Acting Sand Blower, Wilbraham-Green, 7½-hp. West., 3 ph., 60 cy., 220 v., 1700 r.p.m. Allen Bradley Starter.
1—Motor-Driven McGowan Cent. Pump—Dir. con. 15-hp., CCL West. Motor, 3 ph., 60 cy., 220 v., 850 r.p.m. West. Auto Starter 5-15 hp.
1—Motor Driven McGowan Cent. Pump, dir. con. 7½ hp. Wagner Motor, 3 ph., 60 cy., 220 v., 440 v., 1200 r.p.m. West. Auto Starter 5-15 hp.
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2—750 kw. Kerr Turbo Generator Sets.
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All in perfect condition.

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4—500-hp. Heine Water Tube Boiler. Complete with stokers.

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Clayton—75-hp.—Bore 18x12x12-in. stroke, 500 cu.ft., 90 lb. pressure, No. 22940, link belt silent chain drive.
G. E. Motor—75-hp., 3 ph., 60 cy., 440 v., 600 r.p.m.
This Air Compressor is twin stage.

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Compressor No. 1—York—Capacity 70 tons per 24 hours. Cylinder 16 in. dia. x 26 in. stroke, double acting.
Motor: 150-hp., 440 v., 3 ph., 60 cy., 585 r.p.m., Cr.-Wh. slip ring.
Compressor No. 2—York—Capacity 70 tons per 24 hours. Cylinder 16 in. dia. x 26 in. stroke, double acting.
Motor: 125-hp., 440 v., 3 ph., 60 cy., 585 r.p.m. Crocker-Wheeler slip ring.
Above units complete with Condensers, Accumulators, Brine Pumps, etc.

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50-hp., 720 r.p.m., 3/60/220 General Electric.
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150-hp., 600 r.p.m., 3/60/220 Western Electric.

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50-hp., 1800 r.p.m., 3/60/220 Louis-Allis.
50-hp., 900 r.p.m., 3/60/220 Fairbanks-Morse.
75-hp., 900 r.p.m., 3/60/220 General Electric.

SQUIRREL CAGE MOTORS
50-hp., 1200 r.p.m., 3/60/220 Gen. Elec. KT.
60-hp., 900 r.p.m., 3/60/220 Gen. Elec. KT.

A. C. GENERATORS
25 kva., 1800 r.p.m., 3/60/2300 Fairbanks-Morse.
37 kva., 1200 r.p.m., 3/60/220 Burke.
60 kw., 1200 r.p.m., 3/60/440 Allis-Chalmers.

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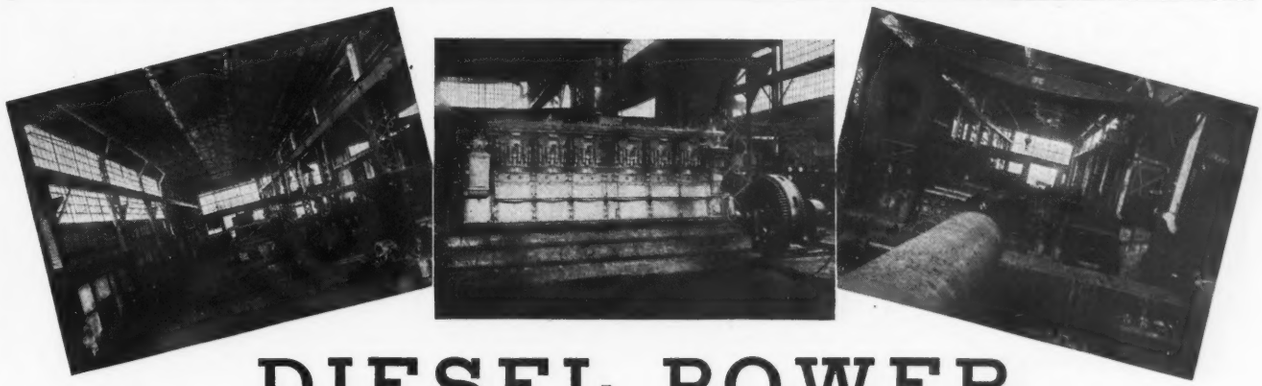

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Engines, Engine Generator Sets, and a complete line of auxiliary equipment, including pumps, compressors, clutches, oil coolers, parts, supplies, etc., are carried in stock.

Units ranging from 1200 hp. to 15 hp. available from stock for prompt shipment, include McIntosh & Seymour, Busch-Sulzer, Fulton, Fairbanks-Morse, Venn Severin, Nelseco, Atlas Imperial, Chicago Pneumatic, Ingersoll-Rand, Superior-Otto, Winton, Cummins, etc.

All equipment thoroughly conditioned by experienced Diesel engine personnel under competent supervision.

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So unusual are these values that a Canadian firm recently purchased a NELSECO Diesel unit from us at a large saving—even after paying heavy freight and import duty charges. Another Diesel unit purchaser saved big money—even after paying the freight charges for delivery to a point in Wyoming. *Total Diesel Sales 1933—8800 H.P.*

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FOR DIESEL ENGINE BUYERS

Fourteen (practically new) 240 hp. NELSECO full Diesel Engines, 8 cylinder, 4 cycle, 9 in. x 12½ in., 360 r.p.m., air or solid injection (Bosch). Right or left hand. Total service averages 800 hours each. New Engine Guarantee.

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1—150-hp. NEW West. Type CS, 3/60/220, 870 r.p.m.
1—125-hp. G. E. Type MT, 3/60/220, 1200 r.p.m.
1—150-hp. West. Type CW, 3/60/440, 585 r.p.m., 3 brg.
1—100-hp. G. E. Type MT, 3/60/220, 870 r.p.m.
1—100-hp. Elec. Machinery Synchronous, 2/60/220, 600 r.p.m.
1— 75-hp. West. Type CI, 3/25/220, 750 r.p.m.
2— 60-hp. West. Type CW, 3/60/220, 870 r.p.m.
2— 50-hp. NEW G. E. Type KT, 3/60/440, 1200 r.p.m.

Smaller Sizes in Stock for Immediate Delivery.

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1—200 kva. Burke Elec., 2/60/220 Unifio Eng.
1—100 kva. Venn-Severin Diesel, 2/60/220.
1—50 kw. G.E., 2/60/220 Ridgeway Engine.
1—32 kw. Fairbanks-Morse Diesel, 3/60/2300.
4—NEW 7½ kw. Watson, 125 v. D.C., with 5x5-in. Vert. Eng.

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1—150 kw. West., 250 v. D.C., 3/60/4100 Synchronous.
1—100 kw. West., 250 v. D.C., 3/60/4100 Synchronous.
2—30 kw. NEW G.E., 250 v. D.C., 3/60/440.

WELDERS

1—1000 amp. West., 3/60/440.
1— 300 amp. West., 3/60/220.
1— 300 amp. Lincoln, 3/60/220.
1— 75 kw. Federal Spot, 45-in. Throat.
1— 35 kw. Taylor-Winfield Portable Spot.

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Limited number for sale at low prices while they last.

4-in. Discharge, 500 G.P.M., 80-ft. head, 15-hp., 220 v., 3 ph., 60 cy.
8-in. Discharge, 1515 G.P.M., 75-ft. head, 46-hp., 220 v., 3 ph., 60 cy.

The above represents a special offering. Send for complete details and specifications.

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1—319-hp. Edge Moor W.T. 200 lb. Press.
1—175-hp. Coatesville 72-in.x20-ft. HRT 150 lb. Press.
2— 80-hp. Coatesville 60-in.x16-ft. HRT 150 lb. Press.
1— 70-hp. Vertical, 54-in.x10-ft., 100 lb. Press.
1— 55-hp. Leffel Scotch Marine, 100 lb. Press.
1— 25-hp. Erie Economic, 125 lb. Press.

STEAM PUMPS

2—NEW 18x12x16 Union Simplex 325-500 G.P.M., 200 lb. Press.
1—16x5½x12 Buffalo Duplex, 500 G.P.M., 1000 lb. Press.
1—10x6x12 Platt Duplex B.F., 150 lb. Press.
1—9x5¼x10 Worthington O.E.P., 250 lb. Press.
1—8x11¾x10 Blake Single Vacuum.
1—6x4x6 Warren Duplex Pot Valve, 250 lb. Press.

AIR COMPRESSORS

1—528-cu.ft. Ingersoll-Rand ER1, 14x12.
1—368-cu.ft. Ingersoll-Rand ER1, 12x10.
1—254-cu.ft. Chicago Pneu., NSB, 10x10.
2—173-cu.ft. Ingersoll-Rand ER1, 9x8.
1—136-cu.ft. Chicago Pneu., NSB, 8x8.
2—100-cu.ft. Ingersoll-Rand Type 20, 3/60/220.

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1—450 hp. Worthington 6 cylinder vertical Solid Injection with direct connected 300 kw. General Electric alternator.
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2—120 hp. Busch Diesel with or without alternator.
1—200 hp. Fairbanks Morse with alternator.
1—120 hp. Busch Diesel.
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1—2500 Kw. Westinghouse 2-3-60-2300 V.
1—1500 Kw. Gen. Elec. 2-3-60-2300 V.
1—1000 Kw. Gen. Elec. 3-60-600 V.
2— 500 Kw. Gen. Elec. 3-60-2300 V.
2— 500 Kw. Gen. Elec. 3-60-600 V.
1— 300 Kw. G.E. (Non Cond.) 3-60-600 V.

Motor Generators

1—750 Kw. G.E. Syn. 3-60-13,200-275 D.C.
1—300 Kw. G.E. Syn. 3-60-600-125-250 D.C.
2—200 Kw. West. 3-60-220 to 275 D.C.
1— 75 Kw. G.E. 3-60-2300 to 125 D.C.

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604 Hp. B.&W. A.S.M.E. 200 lbs.
300 Hp. B.&W. Mass. Std. 160 lbs.

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2—2000 Kva. Wagner 3-60-13, 800/2300 V.
3—333 Kva. G.E. 2200/575 V.
3—125 Kva. G.E. 2200/608 V.
6— 75 Kva. G.E. 1150/2300/4000/115/-230 V.

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SPECIAL BARGAINS

1—1000 KW., 1250 KVA. General Electric High Pressure Condensing Type Turbo Generator Unit, 3 phase, 60 cycle, 2300 volts, 3600 RPM.

1—750 KW. Kerr Allis-Chalmers Mixed Pressure Turbo Generator Unit, 3 phase, 60 cycle, 2300 volts, 3600 RPM.

We have other Turbo Generator Units as well as complete power plants, Boilers, Engine Generator Units, etc.

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500 kw. Westinghouse, 3 phase, 60 cycle generator end, 600 volts, D.C. Automatic switching.

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1—17 kw., 125 v. D.C. stm. Engine Generator Set.
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1—1500 kw. G.E. Turbo Generator Set, 2300 v., 3 ph., 60 cy.

DUQUESNE ELECTRIC & MFG. CO.
Pittsburgh, Pa.

L. J. LAND — *The MOTOR Specialist* — Est. 1910

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230 VOLT, D.C. MOTORS

H.P.	Make	Type	Speed
92	Westinghouse	SK	475/1000
75	Westinghouse	SK	850
80	Elec. Dynam.	258	525/1050
75	Elec. Dynam.	311N	400
60	General Elec.	LC	900
60	General Elec.	RC	650
60	Westinghouse	SK	620
50	General Elec.	CO	725
50	Elec. Dynam.	262N	415
40	General Elec.	LC	700
30	General Elec.	CD	1750
30	Westinghouse	SK	1025
30	Westinghouse	SK	850
30	Elec. Dynam.	....	600
30	Sprague	C	450/1150
20	General Elec.	RC	800
15	Westinghouse	SK	1800
15	Crocker Wheel.	CM	900
15	General Elec.	CO	875/2700
15	General Elec.	RC	850
10	General Elec.	RC	1700
10	General Elec.	RC	1150
10	General Elec.	RC	700
10	Sprague	D	560/1120
10	Westinghouse	SA	500/1000
10	General Elec.	RLC	400/1600
9	General Elec.	RF	450/1800
7½	Westinghouse	HK	800
7½	Westinghouse	SK	650
7½	General Elec.	CR	500/1500
7½	General Elec.	RF	450/1350
5	General Elec.	CD	1800
5	General Elec.	BD	1200
5	Westinghouse	SK	1100

115 VOLTS, D.C. MOTORS

H.P.	Make	Type	Speed
45	Westinghouse	SK	1150
40	General Elec.	CD	400/600
34	General Elec.	RC	1765
31	General Elec.	RC	2200

A.C. SQUIRREL CAGE MOTORS 3 phase, 60 cycle

H.P.	Make	Type	Speed
220	Crocker Wheeler	....	720
150	General Elec.	IK	720
100	Allis Chalmers	AR	1750
75	General Elec.	KT	1200
50	General Elec.	KT	1800
50	General Elec.	KT	900
50	Westinghouse	CS	900
50	Westinghouse	CS	600
40	General Elec.	KT	1800
40	General Elec.	KT	1200
40	General Elec.	KT	900
35	Elec. Dynam.	....	1800
35	General Elec.	KT	1200
30	Westinghouse	CCL	3450
30	Westinghouse	CS	1200
30	General Elec.	KT	1200

A.C. SQUIRREL CAGE MOTORS (Continued)

30	Fairbanks-Morse	B	1200
30	Westinghouse	CS	1200
30	General Elec.	KT	900
30	Wagner	BP	720
30	Allis-Chalmers	....	600
25	General Elec.	KT	1800
25	General Elec.	KT	1200
25	Westinghouse	CS	1200
25	Century	AS	1200
25	Fairbanks-Morse	....	720
25	Westinghouse	CS	600
25	Westinghouse	CS	3450
20	General Elec.	KT	1800
20	Fairbanks-Morse	B	1200
20	Westinghouse	CS	900
20	General Elec.	FTR	900
20	General Elec.	KT	900
17	General Elec.	KTE	1015
15	General Elec.	KT	1800
15	Century	AS	1200
15	Howell	NSC	1200
15	Westinghouse	CS	900
15	General Elec.	KT	900
15	General Elec.	KT	720
15	Fairbanks-Morse	H	600
14½	General Elec.	KTE	1200
10	General Elec.	KT	1800
10	General Elec.	KT	1200
10	Fairbanks-Morse	H	1200
10	Westinghouse	CS	900
10	General Elec.	KT	720
10	General Elec.	KT	600

A.C. SLIPRING MOTORS

H.P.	Make	Type	Speed
200	Fairbanks-Morse	BV	600
200	General Elec.	IM	500
200	General Elec.	IM	900
150	General Elec.	IM	500
100	Northwestern	....	1800
75	Westinghouse	HF	1200
65	Westinghouse	CW	1200
60	General Elec.	MT	900
60	General Elec.	MT	750
50	Wagner	22BBR	1200
50	General Elec.	IM	900
40	General Elec.	MT	1200

A.C. SLIPRING MOTORS (Continued)

40	Lincoln	IXL	720
40	Crocker Wheeler	....	720
35	Westinghouse	CI	975
30	General Elec.	MT	1200
30	Wagner	BR	600
25	Fairbanks-Morse	BV	900
25	Westinghouse	CW	900
20	General Elec.	MT	1200
15	Westinghouse	CW	1800
11	General Elec.	ITC	900
10	General Elec.	IM	900
10	Wagner	BR	900
7½	General Elec.	MT	1800
7½	General Elec.	MT	1200
7½	Westinghouse	CI	1125
7½	General Elec.	MT	900
7½	Howell	....	720
5	General Elec.	MT	900

A.C. SYNCHRONOUS MOTORS

H.P.	Make	Type	Speed
145	General Elec.	ATI	720
225	General Elec.	ATI	900

A.C. GENERATORS (Single 2 and 3 phase)

KW.	Make	Speed
1½	General Elec.	1800
3	Crocker-Wheeler	1800
5	General Elec.	1800
7½	Westinghouse	1800
10	Crocker Wheeler	1800
15	General Elec.	1800
20	Westinghouse	1800
30	General Elec.	1200
50	General Elec.	1200
65	Wagner	1200
108	General Elec.	720
125	Westinghouse	900
150	General Elec.	900
200	Westinghouse	600

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550 VOLTS, D.C. GENERATORS

KW.	Make	Type	Speed
30	Westinghouse	SK	1200
20	General Elec.	RC	1800
5	General Elec.	MCC	1800
1	General Elec.	....	1800
	¼General Elec.	BD	1800

230 VOLTS, D.C. GENERATORS

KW.	Make	Type	Speed
200	Burke	3 wire	900
100	Burke	3 wire	900
50	General Elec.	RC	1200
50	Westinghouse	SK	1200
50	Burke	3 wire	600
32	Westinghouse	....	700
30	General Elec.	C	1200
30	Burke	3 wire	770
15	Westinghouse	SK	1200
10	Westinghouse	SK	900

115 VOLTS, D.C. GENERATORS

KW.	Make	Type	Speed
150	General Elec.	MPC	900
45	General Elec.	CL	975
25	Westinghouse	SK	1200
25	General Elec.	DLC	1200
20	General Elec.	LC	1800
10	General Elec.	MIC	1800
7	General Elec.	MIC	1800
5	General Elec.	CD	1800
3½	General Elec.	CD	1800
3	Westinghouse	SK	1800
1½	Westinghouse	CD	1800

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400 ampere General Electric Welder
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9 x 8 Ingersoll Rand, ERI Air Compressor
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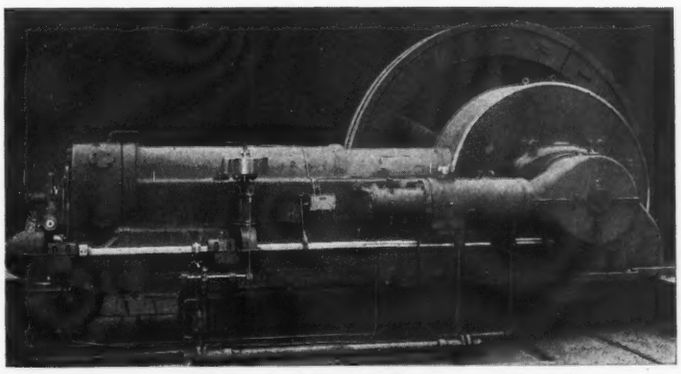

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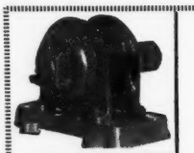

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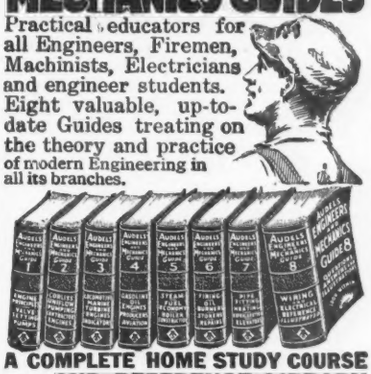

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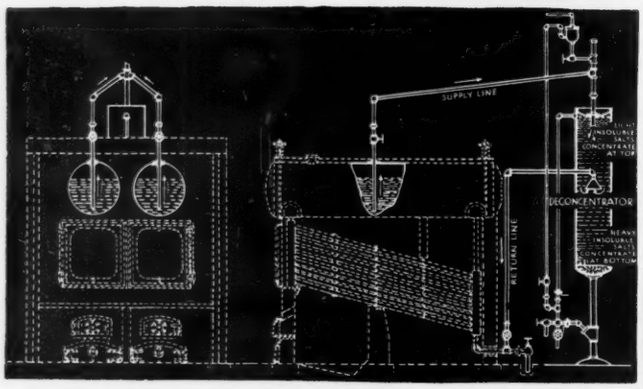

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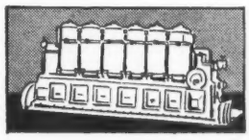

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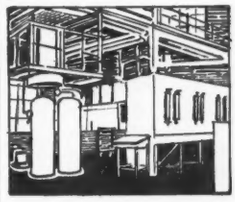

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